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HIGH SOLIDS PRIMERS ENHANCEMENT

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MATERIALS AND MANUFACTURING DIRECTORATE
AIR FORCE RESEARCH LABORATORY
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The objective of this task was to monitor the flight testing of coating systems identified by the HPACS project conducted by Battelle to offer improved film properties of weatherability and cleanability. All tested coatings comply with the 1998 National Emissions Standard for Hazardous Air Pollutants (NESHAP). This project provided a tool for ALCs to implement the best performing commercial "off the shelf" (COTS) coating system available, utilizing the results of these KC-135 flights tests.

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EXECUTIVE SUMMARY

A survey of personnel at USAF ALC and field repaint facilities, identified difficulties being experienced using NESHAP compliant (high solids) primers. The most prevalent complaint was the longer dry time to a topcoat condition required by these primers when compared to low solids primers under other than standard environmental conditions, especially low temperature. The long dry times slow production and allow time for the wet primers to become contaminated. The personnel expressed willingness to accept a two-hour pot-life if dry time could be reduced.

Nine different primers, 6 epoxy and 3 polyurethane, were evaluated for "wet" paint characteristics and final film properties when applied and cured under several environmental conditions. All of the primers were NESHAP compliant. Two epoxy primers were on the Qualified Products List (QPL) for MIL-P-23377G. Four epoxy primers were modified by the manufacturers to achieve faster dry. Two of the polyurethane primers were on the QPL for TT-P-2760A and one was modified by the manufacturer to accelerate the cure.

Within each primer category, no single product performed best under all environmental conditions. In all cases, primers with the lower initial viscosity had a lower viscosity after a two hour pot-life. In general, the primers with the longer pot-life also exhibited longer dry times.

Within each environmental condition, a modified primer was judged to have the best balance between dry time, pot-life, and film properties. However, substantial differences were seen between QPL approved products in differing environmental conditions. Individual painting operations, therefore, have substantial opportunity to improve operations by evaluating the QPL materials available to them and choosing the material that performs best under their specific conditions.

Based upon the testing conducted in this project, potential exists for primers to be formulated for optimum performance under specific environmental conditions. Purchase Descriptions or AMS Specifications for primers could be developed for primers to be applied under specific environmental conditions. These specifications should be tailored for dry time and pot-life under specific temperature and humidity conditions, while maintaining the film performance of the standard QPL primers.

Based on minimizing dry time and viscosity increase, while maintaining acceptable adhesion, the best performing primers under each environmental application and cure condition were:

77°F/50% RH – Epoxy Primer 4 (Sherwin-Williams-modified) offered the best balance of dry time of 3 hours and viscosity of 32 seconds after 2 hours. Polyurethane Primer 7 (Courtaulds-QPL) took 6 hours to dry and possessed a viscosity of 14 seconds after 2 hours.

60°F/20% RH – Epoxy Primer 3 (Dexter-modified) offered the relationship of dry time of 9 hours and viscosity of 25 seconds after 2 hours. No polyurethane primer* was found to be suitable for application under these conditions.

60°F/80% RH – Epoxy Primer 4 (Sherwin-Williams-modified) exhibited a dry time of 6 ½ hours and viscosity of 47 seconds after 2 hours. Polyurethane Primer 7 (Courtaulds-QPL) dried in 5 hours and maintained a viscosity of 16 seconds after 2 hours.

90°F/20% RH – Epoxy Primer 5 (Spraylat-QPL) dried in 3 hours while maintaining a viscosity of 35 seconds after 2 hours. No polyurethane primer* was found to be suitable for application under these conditions.

90°F/80% RH – Epoxy Primer 4 (Sherwin-Williams-modified) dried in 2 hours and possessed a viscosity of 48 seconds after 2 hours. Polyurethane Primer 7 (Courtaulds-QPL) dried in 2 ½ hours and retained a viscosity of 15 seconds after 2 hours.

Unless plural component equipment is utilized, a compromise must be sought between the time required to complete the painting operation and dry time considering the painting climate.

No primer was judged the "best" for film characteristic and wet paint property under all environmental conditions. A more comprehensive test matrix is required to examine other film properties and determine the optimum primer to use under each environmental condition of application and cure.

*Polyurethane Primer 7 (Courtaulds-QPL) was very slow drying. Polyurethane Primers 8 and 9 (Deft-QPL and modified) dried fast, but possessed very short pot-life

1.0 INTRODUCTION

The National Emission Standards for Hazardous Air Pollutants (NESHAP) regulation requires that all facilities engaged, either in part or in whole, in the manufacture or rework of commercial, civil, or military aerospace vehicles or components must be in full compliance by September 1, 1998. To achieve this compliance, the use of corrosion inhibiting primers with a maximum Volatile Organic Compound (VOC) of 340 grams/liter (2.8 pounds/gallon) is required. Substituting high solids materials in applications where the high solvent versions of these primers were in use represents a potential reduction of up to 8400 pounds of VOCs per year at the USAF Air Logistics Centers (ALCs).

Technical problems with high solid, solvent borne primers, both epoxy (MIL-P-23377G Type 1, Class C, "Primer Coating: Epoxy, High Solids") and polyurethane (TT-P-2760A, "Primer Coating: Polyurethane, Elastomeric"), were being experienced at the ALCs, field units, and Air Education and Training Command (AETC). The objective of this project is to address these technical problems of high solids primers in order to expedite the transition of reduced VOC systems to the refinish sites. The long dry time needed before topcoat application increases the chance for the wet primer to become contaminated. Waiting for a dry to topcoat condition reduces the productivity of the paint facility. Environmental conditions in the facility affect dry time. For example, the dry time of polyurethane primers is significantly increased by lack of humidity, even at elevated temperatures. The higher viscosity of high solids, low VOC primers contribute to reduced atomization resulting in a pronounced orange peel appearance of the surface. This resultant orange peel is more apparent when overcoated with high gloss topcoats. Refinishing facilities are restricted from adding solvent to reduce the viscosity, because the paints are formulated at the maximum allowable VOC to remain in compliance; any additional solvent would negate this NESHAP compliance.

2.0 PURPOSE

The purpose of this project was to provide a guide for USAF personnel on dry times of corrosion inhibiting primers when it is necessary to paint aerospace assets under less than ideal environmental conditions.

3.0 SCOPE

The effort of this task was to evaluate dry times of primers that comply with NESHAP regulations. Selected primers from the qualified products list (QPL) for MIL-P-23377G or TT-P-2760A were evaluated. Also, primers modified by the manufacturers to accelerate the dry time were evaluated. Seven major primer suppliers on the QPLs were contacted to submit primers which meet the criteria of reduced dry time to topcoat/tape and a 2-hour minimum pot-life. Assurances by the paint manufacturer were requested that these modifications would not be expected to have a deleterious effect upon the performance of the primers. However, it was not the purpose of this task to perform extensive performance testing or to qualify modified formulations.

The primer suppliers selected were:

Courtaulds Aerospace Inc. (PRC Desoto Int'l)
Deft Coatings
Dexter Aerospace Materials
Sherwin-Williams Co
Spraylat Aerospace Coatings
Sterling Lacquer
U.S. Paint Corporation

The primers selected for this task were:

Primer No.	Specification		Vendor	Manufacturer's Identification	Used
1	MIL-P-23377G	Modified	Courtaulds	RW-3355-64A/B/C	
2	MIL-P-23377G	QPL	Deft	02Y40	GSA Contract Control
3	MIL-P-23377G	Modified	Dexter	10-P20-12	
4	MIL-P-23377G	Modified	Sherwin-Williams	RP2108E90/RP2122V93	
5	MIL-P-23377G	QPL	Spraylat	EEAE154A/B	Randolph AFB
6	MIL-P-23377G	Modified	US Paints	R9007	
7	TT-P-2760A	QPL	Courtaulds	833x089	
8	TT-P-2760A	QPL	Deft	09Y0002	GSA Contract Control
9	TT-P-2760A	Modified	Deft	09Y0002FD	

Included are 2 epoxy primers on the QPL for MIL-P-23377G and 2 polyurethane primers on the QPL for TT-P-2760A. Four epoxy primers and one polyurethane primer were modified by their manufacturer to enhance dry time.

Each of the above primers was evaluated for dry time using the dry time recorder under five different climatic conditions. This information served as a comparison between the primers from a QPL and the modified primers. The climatic conditions for these studies were:

25±3°C (77°±5°F) / 50±5% RH
16±3°C (60°±5°F) / 20±5% RH
16±3°C (60°±5°F) / 80±5% RH
32±3°C (90°±5°F) / 20±5% RH
32±3°C (90°±5°F) / 80±5% RH

During this task, high solids, solvent-borne, chromated primers were evaluated for the following properties:

1. Measurement of dry time (topcoatability), when spray applied, as a function of temperature and humidity. The primed panels remained in a paint booth at low airflow (approximately 45 linear feet/min.) under the above conditions and were topcoated when

judged "dry" by operator touch. Primed panels were topcoated with both camouflage and gloss topcoats under each climatic condition. The gloss topcoat was Deft 03-GY-277, MIL-PRF-85285C, Fed. Standard 595B 16473. The camouflage topcoat used was Deft 03-GY-321, MIL-PRF-85285C, Fed. Standard 595B 36173.

2. Measurement of dry time as a function of temperature and humidity utilizing the Byk Dry Time Recorder. The drying tests were conducted by making two drawdowns on glass and aluminum substrates for each primer. They were cured in an environmental chamber under the above conditions.

3. Measurement of pot-life, via both Ford #4 Viscometer and Brookfield Rotational Viscometer, as a function of time, temperature, and humidity. The primers were mixed and kept under constant agitation in covered containers at each specified environment. Aliquots were removed and measured for viscosity. Viscosities were obtained immediately after mix (or after a dwell time as specified by the manufacturer) and after 1, 2, and 4 hours.

4. Determination of the water resistance as a function of temperature and humidity during application and cure. This test determines compatibility issues of coating systems applied and cured at the environmental conditions. Panels were prepared and cured for a minimum of 14 days under the above climatic conditions and evaluated for water resistance by immersion in 120°F water for 4 days. Each primer was spray applied to 2024 T3 bare aluminum which had been treated with CCC IAW CTIO LP-002 and topcoated with gloss topcoat MIL-PRF-85285. Once removed from the water and dried, the panels were visually inspected for wrinkling, blistering, adhesion loss using cross hatch adhesion (ASTM D3359, Method A), softening using Pencil Hardness (ASTM D 3363) and other loss of integrity. After 24 hours dry time at ambient room temperature, modified PATTI pull-off adhesion tests were performed per CTIO LP-013 .

5. Evaluation of color values as a function of temperature and humidity during application and cure. Each of the primers was topcoated with both gloss and camouflage topcoat. Topcoats used are stated in Test 1.

4.0 TEST SUMMARY

4.1 Dry Time

Details of the dry time when spray applied along with the resultant gloss readings are tabulated in Table 1. The dry times obtained from the Dry Time Recorder are tabulated in Table 2.

When tested under Standard Laboratory Conditions (77° F/50% RH) utilizing the Dry Time Recorder, all of the epoxy primers exhibited a hard dry between 1 and 4 ½ hours. Epoxy Primer 5 (Spraylat-QPL) exhibited the fastest dry time of less than 1 hour. Judging the dry time of the primers after spray application, little differences were noted and each of the epoxy primers was topcoated after 3 to 3 ½ hours. Polyurethane Primers 8 and 9 (Deft-QPL and modified) exhibited

the fastest dry time utilizing the Dry Time Recorder. Polyurethane Primer 7 (Courtaulds-QPL) was slowest with a recorded time of over 6 hours. All of the spray-applied polyurethane primers were topcoated after 4 hours.

Among the epoxy primers when spray-applied at 60°F/20% RH, Primer 4 (Sherwin-Williams-modified) and Primer 5 (Spraylat-QPL) exhibited the fastest dry times, drying in 1 ½ hours. The Dry Time Recorder registered Primer 5 (Spraylat-QPL) to possess the fastest dry time of 6 hours. Among the polyurethane primers, spray applied under these conditions, Primers 8 and 9 (Deft-QPL and modified) exhibited the fastest dry times, 4 hours. The Dry Time Recorder indicated Primer 8 (Deft) to possess the shorter dry time, 12 3/4 hours. Primer 7 (Courtaulds-QPL) exhibited a very slow dry, failing to dry hard during the 24 hour limit of the recorder.

Among the epoxy primers spray-applied at 60°F/80% RH, Primer 2 (Deft-QPL), Primer 3 (Dexter-modified), and Primer 4 (Sherwin-Williams-modified) dried the fastest in 2 ¼ hours. Primer 4 (Sherwin-Williams-modified) exhibited the fastest dry time utilizing the Dry Time Recorder, exhibiting hard dry in 6 ½ hours. Primer 7 (Courtaulds-QPL) dried the fastest among the spray applied polyurethane primers, drying in 3 ½ hours; Primer 8 (Deft-QPL) exhibited the faster dry on the Dry Time Recorder, drying in 3 ½ hours.

Under the environmental conditions of 90°F/20% RH, Primer 4 (Sherwin-Williams-modified) dried the fastest when spray applied, less than 1 hour. All of the epoxy primers appeared to dry in less than 2 ½ hours. Primer 2 (Deft-QPL) recorded the fastest dry time on the Dry Time Recorder, 2 ½ hours. The modified polyurethane Primer 9 (Deft) was judged dry in 1 hour after spray application. The Dry Time Recorder recorded a hard dry of 8 ½ hours for this product.

When spray applied at 90°F/80% RH, no differences were observed between all of the primers, both epoxy and polyurethane, and all were topcoated within 3 hours. Also, the Dry Time Recorder recorded few differences.

Usually the Dry Time Recorder registered longer dry times because the primers were applied by drawdown which maintains higher solvent levels in the film as opposed to spray outs. Less airflow occurs in the controlled environment chamber than in a spray booth.

High Solids Primers

Table 1 - Dry Time Test Matrix - Spray Application

		Primer 1	Primer 2	Primer 3	Primer 4	Primer 5	Primer 6	Primer 7	Primer 8	Primer 9
Condition 1	Dust Free (hours)	2	1	2	1	.7	.7	1	1	1
77°, 50%RH	Tack Free (hours)	2	1	2	1.5	.7	3.5	3	3	3
Mil-C-85285	Recoat (hours)	3	3	3	3	3	3.5	4	4	4
Gloss TC	DFT Primer/Topcoat	.7/2.4	.9/2.3	.8/2.5	.9/2.3	.9/2.4	.9/2.0	.9/2.3	1.3/1.9	1.4/1.9
Color 16473	Gloss, 20°/60°	84.6/91.9	83.5/92.3	86.5/92.2	85.6/92.7	84.7/92.2	85.7/92.5	86.2/92.0	85.8/92.5	85.4/92.2
Camouflage TC	DFT Primer/Topcoat	.7/2.5	.9/2.5	.8/2.4	.9/1.8	.9/2.1	.9/1.8	.9/2.3	1.3/1.9	1.2/2.1
Color 36173	Gloss, 60°/85°	2.4/5.1	1.6/3.4	1.9/4.1	1.8/3.0	2.1/3.0	1.7/2.9	1.2/2.1	1.2/2.2	1.1/1.9
Condition 2	Dust Free (hours)	5	1.4	4	.7	.7	1.5	9	2	1.5
60°F, 20%RH	Tack Free (hours)	6	4	4.5	1	1	3	13	3.5	2
Mil-C-85285	Recoat (hours)	6	6	6	1.5	1.5	5	24	4	4
Gloss TC	DFT Primer/Topcoat	.9/1.32	.9/2.1	.9/1.4	.8/1.6	.9/1.5	.9/2.9	1/3.0	1.5/2.5	1.2/2.5
Color 16473	Gloss, 20°/60°	84.3/92.6	77.7/92.2	73.7/92.7	83.8/92.3	76.1/92.2	86.1/92.6	86.6/91.9	85.5/92.1	86.2/92.6
Camouflage TC	DFT Primer/Topcoat	.8/1.5	.9/1.5	.9/1.4	.7/2.2	.9/1.7	.8/1.6	1.1/2.5	1.3/2.1	1.6/2.3
Color 36173	Gloss, 85°/60°	4.6/3.0	2.4/1.3	4.0/3.0	2.6/1.3	4.3/2.4	3.4/2.2	mud cr.	2.8/1.6	3.5/2.1
Condition 3	Dust Free (hours)	-	.5	.5	.5	1	1	1	1.3	1.3
60°F, 80%RH	Tack Free (hours)	-	1.5	1.5	1.5	6	3	2.5	3.2	3.2
Mil-C-85285	Recoat (hours)	-	2.2	2.2	2.2	6	4	3.3	4	4
Gloss TC	DFT Primer/Topcoat		.8/1.7	.6/2.0	.6/1.8	.9/1.6	.9/1.7	1.6/1.6	1/1.6	1.1/2.2
Color 16473	Gloss, 20°/60°		73.4/92..2	83.9/92.1	82.3/91.6	73.2/91.3	76.8/91.7	83.0/91.3	82.1/91.5	83.6/91.7
Camouflage TC	DFT Primer/Topcoat		.8/2.2	.6/2.0	.6/2.0	.9/1.6	.9/1.7	1.2/2.0	1.1/2.2	1.1/2.0
Color 36173	Gloss, 85°/60°		1.7/0.9	2.6/1.7	2.0/1.0	2.5/1.6	3.2/2.2	1.8/1.0	1.6/0.7	1.6/0.7
Condition 4	Dust Free (hours)	.5	.5	.5	.4	.7	.8	1	1	.5
90°F, 20%RH	Tack Free (hours)	.7	1	1.5	.5	2	1	5.5	1.5	.8
Mil-C-85285	Recoat (hours)	1.2	1	1.8	.8	2.3	2	6.2	2.2	1
Gloss TC	DFT Primer/Topcoat	.7/2.0	.8/1.9	.9/1.9	.9/2.0	.9/2.3	.8/2.3	.9/2.7	1.3/2.2	1.4/2.3
Color 16473	Gloss, 20°/60°	85.0/91.7	83.1/92.1	98.4/92.1	99.4/92.0	86.1/92.2	85.4/92.2	87.6/92.5	85.6/92.0	86.0/92.3
Camouflage TC	DFT Primer/Topcoat	.7/2.4	.8/2.4	.8/2.4	.9/2.3	.8/2.1	.9/2.2	.9/2.7	1.4/2.3	1.2/2.5
Color 36173	Gloss, 85°/60°	4.2/2.4	4.1/2.4	5.1/3.0	4.3/2.3	4.7/2.7	4.4/2.9	3.8/2.0	3.0/1.4	3.6/2.0
Condition 5	Dust Free (hours)	1	1	1	1	1	1	1	1	1
90°F, 80%RH	Tack Free (hours)	1.5	1.5	1.5	1.5	1.5	1.5	1	1	1
Mil-C-85285	Recoat (hours)	3	3	3	3	3	3	3	3	3
Gloss TC	DFT Primer/Topcoat	.7/1.5	.7/1.5	.6/1.7	.7/1.7	.9/1.5	.8/1.5	1.2/2.2	1.6/1.7	2.0/1.9
Color 16473	Gloss, 20°/60°	78.1/90.5	75.5/89.5	64.0/86.0	71.3/89.6	78.3/90.3	79.9/91.0	82.6/91.4	77.5/90.4	79.8/91.2
Camouflage TC	DFT Primer/Topcoat	.7/1.6	.7/1.7	.7/1.7	.7/2.6	.9/1.9	.7/1.8	1.1/2.3	1.9/1.9	2.2/1.5
Color 36173	Gloss, 85°/60°	2.5/1.6	4.7/1.5	6.2/1.9	2.4/1.1	2.5/1.2	2.5/1.3	2.7/1.5	2.3/0.9	2.4/1.0

Table 2 - Dry Time Test Matrix - Dry time Recorder

	Hours	Primer 1	Primer 2	Primer 3	Primer 4	Primer 5	Primer 6	Primer 7	Primer 8	Primer 9
Condition 1 77°F, 50%RH	Wet Edge	.4	0	.9	.1	.1	.2	1.1	.5	.5
	Set Time	1.4	1.4	1.5	.4	.4	1.9	2.6	1.8	1.4
	Tack Free	2.3	1.6	1.6	1.5	.5	2.3	5	2.8	2.3
	Recoat-Fighters	2.8	2.5	2.5	2	.8	3.3	5.4	2.9	2.8
	Recoat-Heavies	4	3.3	4.5	2.6	.9	3.9	>6	3.8	4
Condition 2 60°F, 20%RH	Wet Edge	.5	0	2.0	0	0	1.9	6	1.2	1.1
	Set Time	3.2	3.5	4.7	1.0	1.7	4.8	20	4.3	3.7
	Tack Free	4.5	5.0	5.7	3.5	3.4	6.3	22	6.3	6.3
	Recoat-Fighters	8.0	6.7	6.2	5.5	4.3	7.4	24+	8.5	10.0
	Recoat-Heavies	11.7	9.1	9.0	8.9	6.0	9.7	24+	12.8	18.0
Condition 3 60°F, 80%RH	Wet Edge	-	0	1.4	0	0	0	1.0	0.8	0.4
	Set Time	-	1.2	2.6	1.2	2.9	4.4	1.9	1.4	1.0
	Tack Free	-	2.5	3.8	2.4	3.9	6.4	3.3	1.8	1.4
	Recoat-Fighters	-	5.1	5.0	3.7	6.7	20	4.0	2.4	2.0
	Recoat-Heavies	-	6.5	12	6.5	24	24+	4.9	3.5	3.8
Condition 4 90°F, 20%RH	Wet Edge	.5	0	0.8	0	0.4	0.5	4.3	1.4	1.8
	Set Time	2.0	1.1	1.5	1.2	1.8	1.5	9.0	3.9	3.3
	Tack Free	2.5	1.8	1.9	2.0	2.0	1.8	12.0	4.5	4.0
	Recoat-Fighters	3.5	2.0	3.0	2.5	2.5	2.4	12.4	6.5	5.4
	Recoat-Heavies	5.3	2.6	5.8	5.5	3.0	5.5	14.9	10.3	8.4
Condition 5 90°F, 80%RH	Wet Edge	.3	.6	.4	.12	.3	.6	.2	.7	.5
	Set Time	.5	.8	.6	.9	.6	1.2	.5	.9	.8
	Tack Free	1.0	1.9	.8	1.0	.7	1.2	.8	1.1	.9
	Recoat-Fighters	1.4	1.8	1.3	1.2	1.4	1.7	1.5	1.6	1.2
	Recoat-Heavies	1.7	2.4	1.9	1.4	1.9	1.9	2.3	1.8	1.3

4.2 Viscosity and Pot-life

Details of the viscosity data utilizing the Ford #4 cup and pot-life are tabulated in Table 3. Readings that fail to meet the initial viscosity and 2 hour pot-life are shaded. Most of the short pot-life readings were recorded for conditions other than standard laboratory conditions (77°F/50% RH).

Graphs comparing the viscosity of the primers as a function of time, temperature, and humidity are charted in Appendix I.

Rotational viscosities using the Brookfield viscometer are tabulated in Appendix II. Rotations were accomplished from 10 RPM to 250 RPM returning to 10 RPM in 40 RPM increments. Both the viscosity in centipoise and shear stress in dynes per square centimeter are reported. This illustrates the shear thinning and recovery of the wet primers under the different environmental conditions. Some epoxy primers exhibited shear thinning. Other epoxy primers were Newtonian with the viscosity remaining constant at varying shear rates. The polyurethane primers were predominately Newtonian under all temperature and humidity conditions.

When tested under Standard Laboratory Conditions (77 °F/50% RH) the initial Ford #4 viscosity of each primer met the appropriate specification requirement for epoxy primer (MIL-P-23377G)(40 seconds maximum) or polyurethane primer (TT-P-2760A)(30 seconds maximum). The Ford #4 viscosity of the epoxy primers ranged from 13.8 to 29.1 seconds with Primer 3 (Dexter-modified) being the lowest in viscosity initially and the lowest after 2 hour pot-life (20.6 seconds). After two hours under Standard Laboratory Conditions the viscosities of all of the epoxy primers remained within the pot-life guidelines of 70 seconds. Primer 7 (Courtaulds-QPL) possessed the lowest viscosity of the polyurethane primers initially (12.1 seconds) and the lowest after 2 hour pot-life (14.2 seconds). Primers 8 and 9 (Deft-QPL and modified) exhibited viscosities exceeding 100 seconds after 2 hours and were solid at 4 hours.

When tested under other environmental conditions, the initial viscosity of each epoxy primer was within the specification MIL-P-23377G (40 seconds), with one exception - Primer 5 (Spraylat-QPL) at 60°F/20% RH. It had an initial viscosity of 53 seconds using the Ford #4 cup. Under other environmental conditions, the viscosities of all the primers ranged from a low of 13.8 seconds to the high of 53 seconds. Epoxy Primer 3 (Dexter-modified) possessed the lowest viscosity in four environments and only slightly higher at 90°F/20% RH than Primer 1 (Courtaulds-modified). Primer 1 (Courtaulds-modified) exhibited slightly lower viscosity under that condition. The greatest retention of viscosity stability for the polyurethane primers was Primer 7 (Courtaulds-QPL). In each case the lower the initial viscosity, the lower the viscosity after 2 hours, when tested throughout all of the selected environmental conditions.

Table 3 - Potlife (via Ford Cup) Test Matrix

	Seconds	Primer 1	Primer 2	Primer 3	Primer 4	Primer 5	Primer 6	Primer 7	Primer 8	Primer 9
Condition 1	Viscosity @ 0 hr	16.4	29.1	13.8	20.8	16.9	17.6	12.1	21.2	20.7
77°F, 50%RH	Viscosity @ 1 hr	19.2	27.8	15.9	26.3	27.9	26.3	14.3	52.0	48.1
	Viscosity @ 2 hr	25.3	46.7	20.6	31.7	61.5	31.7	14.2	100+	92.9
	Viscosity @4 hrs	62.4	64.4 s	39.6	48.1	solid	48.1	20.4	solid	solid
Condition 2	Viscosity @ 0 hr	26.2	39.5	17.0	26.8	33.0	20.0	13.1	28.7	28.7
60°F, 20%RH	Viscosity @ 1 hr	39.9	100+	21.8	51.5	100+	50.4	13.4	96.0	72.0
	Viscosity @ 2 hr	52.1	100+	25.3	100+	100+	100+	13.4	100+	100+
	Viscosity @4 hrs	100+	100+	100+	100+	solid	solid	15.3	solid	100+
Condition 3	Viscosity @ 0 hr	-	40.2	15.9	26.2	24.3	19.2	13.1	26.7	29.7
60°F, 80%RH	Viscosity @ 1 hr	-	48.3	18.5	33.4	30.6	28.7	13.6	41.2	85.2
	Viscosity @ 2 hr	-	67.1	23.3	46.9	36.7	67.6	16.1	63.2	100+
	Viscosity @4 hrs	-	100+	67.3	66.8	51.8	100+	48.0	100+	100+
Condition 4	Viscosity @ 0 hr	13.8	26.1	14.2	20.1	19.7	15.9	12.2	20.8	37.4
90°F, 20%RH	Viscosity @ 1 hr	20.7	67.5	32.7	36.3	23.9	36.7	12.9	41.5	solid
	Viscosity @ 2 hr	23.5	100+	100+	56.9	34.4	100+	16.7	100+	solid
	Viscosity @4 hrs	100+	100+	100+	100+	solid	solid	51.8	solid	solid
Condition 5	Viscosity @ 0 hr	15	26	14	18	20	15	11	18	18
90°F, 80%RH	Viscosity @ 1 hr	23	100+	21	24	53	41	12	100+	57
	Viscosity @ 2 hr	51	100+	44	48	100+	100+	15	solid	100+
	Viscosity @4 hrs	solid	solid	solid	100+	solid	solid	38	solid	solid

4.3 Color

The CIELab color values of the paint system were not affected by the different high solid primers when cured under the differing climatic conditions.

Individual readings for each paint system utilizing each primer at each environment are available in Appendix III. Using sphere based color spectrophotometer, the color space reported is L* a* b*. The settings were specular component included, 10°observer, light source D65 (daylight).

4.4 Adhesion and Water Immersion Resistance

Resistance to water immersion varied between the primers tested and with the environmental conditions under which each was applied and cured. The following observations of adhesion combining, Fed. Test Method Std. No. 141C, Method 6301.2 and ASTM D 3359, Method A-X Cut Tape Test were made. The final configuration consisted of 2 parallel cuts with an "X" cut intersecting both parallel cuts.

- Primer 1 (Courtaulds-modified) exhibited poor adhesion, with a rating of 1, initially when applied at standard laboratory conditions. Painted panels with this primer cured under all conditions failed water immersion attaining ratings ranging from 0 to 1.
- Primer 2 (Deft-QPL) failed adhesion after water immersion, with a rating of 0, when applied and cured at 90°F/80% RH.
- Primer 2 and Primer 3 (Dexter-modified) exhibited moderate adhesion (rating 3) initially when applied at 77°F/50% RH, but improved after water immersion, attaining a rating of 4+.
- Primer 4 (Sherwin-Williams-modified) showed moderate adhesion after water immersion (rating 3) when applied and cured at 90°F/80% RH.
- Primer 5 (Spraylat-QPL) exhibited good to excellent adhesion (rating 4+ to 5) both initially and following water immersion when applied and cured at all five environments.
- Primer 6 (US Paints-modified) showed poor adhesion (rating 0) following water immersion when applied and cured at 60°F/80% RH.
- Primer 7 (Courtaulds-QPL) and Primer 8 (Deft-QPL) exhibited excellent adhesion (rating 5) initially and following water immersion when applied and cured under all 5 environmental conditions.
- Primer 9 (Deft-modified) possessed moderate adhesion (rating 3+) initially and poor adhesion (rating 1) after water immersion when applied and cured at 90°F/20% RH.

Blistering was prevalent among all of the primers. Each primer showed some degree of blistering when applied and cured under some environments. See Table 4 for individual occurrences.

4.4.1 Pencil Hardness

Individual values for each primer when cured under each environment are tabulated in Table 4. This testing was accomplished immediately after the panels were removed from the water and dried with a towel. In general, Primer 2 (Deft-QPL) exhibited the lowest (softer) values, ranging from F to 3H; Primer 6 (US Paints-modified) presented the highest (harder) values for the epoxy primers, ranging from F to 4H. Primer 7 (Courtaulds-QPL) was the softest polyurethane primer with values from B to 3H. All of the primers became softer following water immersion losing an average of 3 pencil hardness units.

4.4.2 Modified PATTI Test

Table 4 gives the details of testing accomplished before and following water immersion.

Panels were immersed in deionized water for 4 days at 120°F, removed, adhered to a solid base, and studs bonded to the paint system. The next day the PATTI values were obtained. The following results were observed when the coating systems were applied and cured at these environments:

- 77°F/50% RH - all of the primers performed approximately the same before and after water immersion.
- 60°F/20% RH - the PATTI values for all the primers dropped substantially between initial and following water immersion.
- 60°F/80% RH - the values were mixed.
- 90°F/20% RH - the values increased significantly between unexposed and exposed panels.
- 90°F/80% RH - the values decreased significantly for all of the primers.

Graphs in Appendix IV compare the PATTI results of each primer and gloss topcoat system applied and cured at each condition without water immersion. Appendix V contains charts comparing the PATTI results of each primer and gloss topcoat applied and cured at each condition after exposure to water immersion.

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Table 4 - Water Resistance Test Matrix

			Primer 1	Primer 2	Primer 3	Primer 4	Primer 5	Primer 6	Primer 7	Primer 8	Primer 9
Condition	Initial	Pencil Hardness	3H	3H	4H	4H	3H	4H	H	4H	3H
1	Exposed	Pencil Hardness Softening/Wrinkling	F	2B	B	B	B	F	3B	B	HB
77°F,		Blistering (y/n)	n	n	n	y	n	n	n	y	y
50% RH	Initial	Adhesion/Crosshatch	1	3	3	4	4+	5	5	5	5
	Exposed	Adhesion/Crosshatch	1	4+	4+	5	5	4	5	5	5
	Initial	PATTI adhesion	956.7	983.7	916.3	930.2	967.8	793.0	897.5	771.3	762.0
	Exposed	PATTI adhesion	944.1	814.0	-741.9	847.7	890.2	768.2	820.8	854.2	833.8
Condition	Initial	Pencil Hardness	F	F	F	3H	H	3H	F	H	H
2	Exposed	Pencil Hardness Softening/Wrinkling	F	B	H	F	B	HB	<2B	F	HB
60°F,		Blistering (y/n)	y	y	y	y	n	n	y	y	y
20%RH	Initial	Adhesion/Crosshatch	4+	4+	4+	5	5	5	5	5	5
	Exposed	Adhesion/Crosshatch	2	5	5	5	5	5	5	5	5
	Initial	PATTI adhesion	2670.5	1764.0	1862.0	2621.5	2352.0	2229.5	1617.0	2205.0	1837.5
	Exposed	PATTI adhesion	947.3	800.3	792.2	759.5	971.8	767.7	375.7	865.7	857.5
Condition	Initial	Pencil Hardness		3H	3H	3H	3H	F	B	F	H
3	Exposed	Pencil Hardness Softening/Wrinkling	-	B	F	H	F	F	B	F	F
60°F,		Blistering (y/n)	-	y	y	y	y	y	n	n	n
80%RH	Initial	Adhesion/Crosshatch	-	4+	4+	4+	4+	5	5	5	5
	Exposed	Adhesion/Crosshatch	-	4+	4+	4+	5	0	5	5	5
	Initial	PATTI adhesion	-	514.5	735.0	882.0	890.0	612.5	808.5	1053.5	882.0
	Exposed	PATTI adhesion	-	873.8	1078.0	1200.5	775.8	392.0	963.7	710.5	882.0
Condition	Initial	Pencil Hardness	H	2H	2H	3H	2H	3H	3H	4H	3H
4	Exposed	Softening/Wrinkling Pencil Hardness	B	2B	2B	B	HB	H	2B	B	F
90°F,		Blistering (y/n)	y	y	y	y	y	y	y	y	y
20% RH	Initial	Adhesion/Crosshatch	5	4+	4+	5	5	5	5	5	3+
	Exposed	Adhesion/Crosshatch	1	4+	4	4+	5	5	5	5	1
	Initial	PATTI adhesion	595.4	656.6	798.7	617.4	367.0	654.2	590.5	490.0	401.8
	Exposed	PATTI adhesion	2027.8	1214.4	1498.6	1400.6	2065.4	2146.2	1504.3	2396.9	1674.2
Condition	Initial	Pencil Hardness	2H	3H	4H	F	4H	3H	3H	2H	H
5	Exposed	Pencil Hardness Softening/Wrinkling	F	<2B	B	B	F	F	HB	HB	2B
		Blistering (y/n)	n	n	n	y	n	n	n	n	n
90°F,	Initial	Adhesion/Crosshatch	4	4	4+	5	4+	5	5	5	5
80% RH	Exposed	Adhesion/Crosshatch	0	0	3	3	5	4+	5	5	5
	Initial	PATTI adhesion	2303.0	2731.8	2548.0	1935.5	2486.8	2560.3	2486.8	2058.0	2254.0
	Exposed	PATTI adhesion	1029.0	530.8	1045.3	612.5	939.2	1094.3	1029.0	1069.8	922.8

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Table 5 - Dry Time vs Ford #4 Viscosity										
		Primer 1	Primer 2*	Primer 3	Primer 4	Primer 5*	Primer 6	Primer 7*	Primer 8*	Primer 9
Condition 1	Dry Time (hours)	4	3.3	4.5	2.6	.9	3.9	6+	3.8	4
77°F, 50%RH	Ranking	5th	3rd	2nd	1st	6th	4th	slow	potlife	potlife
	Viscosity @ 2 hrs (seconds)	25.3	46.7	20.6	31.7	61.5	31.7	14.2	100+	92.9
Condition 2	Dry Time (hours)	11.7	9.1	9.0	8.9	6.0	9.7	24+	12.8	18
60°F, 20%RH	Ranking	2nd	potlife	1st	potlife	potlife	potlife	slow	potlife	potlife
	Viscosity @ 2 hrs (seconds)	52.1	100+	25.3	100+	100+	100+	13.4	100+	100+
Condition 3	Dry Time (hours)	-	6.5	12	6.5	24	24+	4.9	3.5	3.8
60°F, 80%RH	Ranking		2nd	3rd	1st	4th	5th	1st	2nd	potlife
	Viscosity @ 2 hrs (seconds)	-	67.1	23.3	46.9	36.7	67.6	16.1	63.2	100+
Condition 4	Dry Time (houts)	5.3	2.6	5.8	5.5	3.0	5.5	14.9	10.3	8.4
90°F, 20%RH	Ranking	2nd	potlife	potlife	3rd	1st	potlife	slow	potlife	potlife
	Viscosity @ 2 hrs (seconds)	23.5	100+	100+	56.9	34.4	100+	16.7	100+	solid
Condition 5	Dry Time (hours)	1.7	2.4	1.9	1.4	1.9	1.9	2.3	1.8	1.3
90°F, 80%RH	Ranking	3rd	potlife	2nd	1st	potlife	potlife	1st	potlife	potlife
	Viscosity @ 2 hrs (seconds)	51	100+	44	48	100+	100+	15	solid	100+

*Denotes primers on respective QPL
Primers are ranked numerically, "potlife" indicates unacceptability due to primer viscosity too high to spray after 2 hours
Shaded values denote viscosity greater than 100 seconds and viscosity test was terminated

5.0 SUMMARY COMPARING DRY TIME WITH VISCOSITY STABILITY AND FILM PERFORMANCE

Table 5 tabulates these observations ranking the epoxy primers and the polyurethane primers according to dry time and Ford #4 viscosity.

If the predominant environment of application and cure is 77°F/50% RH, all of the epoxy primers dried satisfactorily to be topcoated in approximately 4 hours. Primer 3 (Dexter-modified) was the lowest in viscosity and exhibited the longest pot-life of the epoxy primers. It exhibited moderate adhesion (rating 3) initially, but improved after water immersion (rating 4+).

Polyurethane Primer 7 (Courtaulds-QPL) required over 6 hours to obtain hard dry, but was lowest in viscosity and possessed the longest pot-life.

Under low temperature, low humidity (60°F/20% RH), all of the primers required additional time to dry. Primer 5 (Spraylat-QPL) dried the fastest (6 hours), but was the highest in viscosity and exhibited a short pot-life. Primer 3 (Dexter-modified) dried in 9 hours and maintained excellent pot-life.

All of the polyurethane primers cured very slowly, the fastest drying was Primer 8 (Deft-QPL), which required 13 hours for hard dry and was high in viscosity with short pot-life. Primer 7 (Courtaulds-QPL) did not dry within 24 hours, but possessed excellent viscosity stability. When Primer 7 (Courtaulds-QPL) was spray applied and cured at low temperature, low humidity, it was topcoated after 24 hours. When topcoated with gloss topcoat, the appearance was good and the surface was hard. When topcoated with camouflage topcoat, the topcoat remained soft after 36 hours at ambient room temperature with a mud-cracked appearance. After 72 additional hours at ambient room temperature the surface was hard, but retained a mud-cracked appearance.

At low temperature and high humidity (60°F/80% RH), epoxy Primer 4 (Sherwin-Williams-modified) exhibited the shortest dry time and maintained a good pot-life stability, within the specification.

Polyurethane Primer 8 (Deft-QPL) dried the fastest of the polyurethane primers and demonstrated a good pot-life. Primer 7 (Courtaulds-QPL) dried almost as fast and was substantially lower in viscosity.

At high temperature and low humidity (90°F/20% RH), Primer 2 (Deft-QPL) dried the fastest, but possessed a short pot-life. Primer 5 (Spraylat-QPL) dried in 3 hours and maintained good viscosity stability.

The polyurethane primers dried slowly with Primer 9 (Deft-modified) drying in 9 hours, but increased in viscosity rapidly and exhibited poor adhesion (rating 1) after water immersion. Primer 7 (Courtaulds-QPL) maintained excellent pot-life, but required 15 hours to achieve hard dry.

At high temperature, high humidity (90°F/80% RH), all of the primers dried between 1 ½ and 2 ½ hours. Primer 3 (Dexter-modified) maintained the lowest viscosity and pot-life of the epoxy primers. Primer 7 (Courtaulds-QPL) maintained the lowest viscosity of the polyurethane primers.

6.0 DISCUSSION

All of the epoxy primers, both modified and QPL, gave similar dry time when evaluated under standard formulation and qualification conditions (77 °F/50% RH). At different application and cure conditions, however, performance varied significantly between the materials, with no particular pattern, and no particular primer proving superior in all cases. No one epoxy primer of the 6 tested was best under all conditions.

Under the environmental condition of 77°F/50% RH, all of the epoxy primers dried satisfactorily to be topcoated in approximately 4 hours. Film performance properties of all but one were also very similar. Primer 1 (Courtaulds-modified) gave poor adhesion under all application/cure conditions. Primer 3 (Dexter-modified) was the lowest in viscosity (13.8 seconds) and exhibited the lowest viscosity (20.6 seconds) after 2 hour pot-life of the epoxy primers. Primer 3 exhibited moderate adhesion (rating 3) initially, but improved after water immersion.

Under low temperature, low humidity (60°F/20% RH), all of the primers required additional time to dry. Epoxy Primer 5 (Spraylat-QPL) dried the fastest (6 hours measured using the Dry Time Recorder), but was the highest in viscosity (53 seconds) and exhibited a short pot-life with viscosity exceeding 100 seconds after only 1 hour. Primer 4 (Sherwin-Williams-modified) dried in 9 hours, measured by the Dry Time Recorder, and exhibited a short pot-life (100+ seconds after 2 hours). Both were judged dry by the painter when spray applied after 1.5 hours. Primer 3 (Dexter-modified) maintained a lower viscosity after 2 hour pot-life (25 seconds), dried in 9 hours using the Dry Time Recorder, and was judged dry by the painter when spray applied after 6 hours.

Under low temperature and high humidity (60°F/80% RH), Primer 4 (Sherwin-Williams-modified) exhibited the shortest dry time (6.5 hours) and maintained a good pot-life stability (46.9 seconds), within the specification.

Under other than standard conditions, the pot-life of the various epoxy primers is inconsistent, with no material exhibiting satisfactory performance across all conditions. The 60°F/20%RH environment was the most difficult in which to achieve a viscosity of less than 70 seconds on the Ford #4 cup after a 2 hour pot-life. All 6 epoxy primers exhibited satisfactory viscosity on the Ford #4 cup after 2 hour pot-life under 60°F/80% RH environmental condition.

Under high temperature and low humidity (90°F/20% RH), Primer 2 (Deft-QPL) dried the fastest (2.6 hours using the Dry Time Recorder and 1 hour when spray applied), but possessed a short pot-life. Primer 5 (Spraylat-QPL) dried in 3 hours using the Dry Time Recorder and 2.3 hours when spray applied, while maintaining good viscosity stability. All of the epoxy primers where judged dry by the painter when spray applied after 2 ½ hours. The Dry Time Recorder registered a hard dry for all of the primers within 6 hours ranging from 2.6 hours to 5.8 hours.

Under high temperature, high humidity (90°F/80% RH), all of the primers dried between 1 ½ and 3 hours. Primer 3 (Dexter-modified) maintained the lowest viscosity and pot-life of the epoxy primers. The initial viscosity was 14 seconds and increased to 44 seconds after 2 hour pot-life. The only other primer to perform under this condition was Primer 4 (Sherwin-Williams-modified). All of the other epoxy primers had a very short pot-life or exhibited poor adhesion.

These inconsistencies are the result of a complex function of the influence of temperature and humidity on physical and chemical properties of the coatings in the bulk and applied phases. In general, the rate of cure of epoxy coatings is inversely proportional to humidity, and directly proportional to temperature. Higher temperatures and lower humidities will also result in faster solvent evaporation, leading to a faster apparent dry time for any particular formulation. Any particular formulation, at a particular state of cure will exhibit higher viscosity at lower temperatures.

Different materials developed to meet a set of dry time and pot-life performance specifications under one set of environmental application and cure conditions vary widely when these conditions are changed. This is not a reflection on the quality of any formulation, but rather a result of the particular choices in materials used to formulate the coating to meet established specifications.

A modified epoxy primer was ranked higher than either of the QPL primers tested under all but one of the environmental conditions (90°F/20% RH). Clearly, primer modifications show promise of reducing dry time, possessing low initial viscosity and retaining sufficient viscosity stability to provide a 2 hour pot-life. However, Primer 1 (Courtaulds-modified) exhibited poor adhesion under all application/curing conditions. This underscores the need for complete qualification testing of any modified formulation considered for use.

From the different results seen with the two epoxy primers on the QPL for MIL-P-23377G it is apparent that individual installations painting under conditions closer to those represented by the corners of the environmental envelope will experience different dry times. They may find that QPL approved materials from some manufacturers could meet their specific needs better than others, although as environmental conditions change throughout the year at a given location (i.e. summer vs. winter) the performance of material from a particular source may change.

When tested under 77°F/50% RH, polyurethane Primer 7 (Courtaulds QPL) required over 6 hours to obtain hard dry, but was lowest in viscosity (12.1 seconds) and possessed the lowest viscosity after 2 hours pot-life (14.2 seconds).

Under low temperature, low humidity (60°F/20% RH), all of the polyurethane primers cured very slowly, the fastest Primer 8 (Deft-QPL) required 13 hours for hard dry and was high in initial viscosity (28.7 seconds) with short pot-life (over 100 seconds viscosity after 2 hours). Primer 7 (Courtaulds-QPL) did not dry within 24 hours, but possessed excellent viscosity stability, with an initial viscosity of 13.1 seconds and 13.4 seconds after 2 hour pot-life.

Under low temperature, high humidity environmental condition (60°F/80% RH), Primer 8 (Deft-QPL) dried the fastest of the polyurethane primers, drying in 2.4 hours, and demonstrated a good viscosity stability increasing from 26.7 seconds initially to 63.2 seconds after 2 hour pot-life. Primer 7 (Courtaulds-QPL) dried almost as fast (4 hours) and was substantially lower in viscosity, increasing from 13.1 seconds initially to 16.1 seconds after 2 hours pot-life.

Under high temperature, low humidity environmental condition (90°F/20% RH), the polyurethane primers dried slowly with Primer 9 (Deft-modified) drying in 9 hours, but increasing in viscosity rapidly from 20.8 seconds initially to over 100 seconds after 2 hour pot-life. Primer 7 (Courtaulds-QPL) maintained excellent viscosity stability increasing from 12.2 seconds initially to 16.7 seconds after 2 hour pot-life. It required 15 hours to achieve hard dry.

Under high temperature, high humidity environmental conditions (90°F/80% RH), all of the polyurethane primers dried between 1 1/2 and 2 1/2 hours. Primer 7 (Courtaulds-QPL) maintained the lowest viscosity of the polyurethane primers, increasing from 11 seconds initially to 15 seconds after 2 hour pot-life.

The results seen from the evaluation of the polyurethane primers show the drying time is very susceptible to changes in moisture content of the air. Again, different formulations are affected differently. At standard conditions of 77°F/50% RH, both the QPL materials tested were very similar in dry time and film performance properties. The dry times of both were increased under low humidity conditions, but under low temperature and low humidity, Primer 7 (Courtaulds-QPL) dried substantially slower (well over 24 hours) than the Primer 8 (Deft-QPL). However, Primer 7 (Courtaulds-QPL) exhibited excellent pot-life under all environmental conditions, while the Deft primers, both QPL and modified, were borderline at best. Primer 9 (Deft-modified) did exhibit faster dry time, but at a significant sacrifice in pot-life.

As with the epoxies, there appears to be a potential for improvement of operations through the selection of QPL primers whose performance characteristics fit best with the conditions of application. A conscious trade-off must be evaluated between dry time and pot-life under the specific conditions encountered in the facility.

Modified epoxy primers show promise to reduce the dry time, possess low viscosity, and retain viscosity stability over a 2 hour pot-life. Additional testing is needed to determine other rheological characteristics and explore additional film properties.

For the polyurethane primers, Primer 7 (Courtaulds-QPL) maintained the lowest viscosity and longest pot-life, but was very slow drying in the absence of humidity. Even at 50% RH it dried slowly. At 80% RH, Primer 7 exhibited adequate dry times, and maintained stable viscosity. The Deft polyurethane primers appeared to be less sensitive to the lack of humidity, but the viscosity was higher initially and climbed rapidly, exhibiting poor pot-life. The modified version offered little advantage.

In general, the longer the pot-life or viscosity stability as a function of time, the longer the dry time. It is then necessary to make a compromise and choose the most desirable property, taking into consideration the other innate properties. If two-component equipment is available, pot-life

is less important. The length of time to perform the painting operation may be of prime consideration.

7.0 CONCLUSIONS

Based on dry time and viscosity data, mindful of adhesion data, the best performing primers under each environmental condition were:

77°F/50% RH – Epoxy Primer 4 (Sherwin-Williams-modified) offered the balance of dry time of 3 hours and viscosity of 32 seconds after 2 hours. Of the epoxy primers tested on the QPL, Primer 2 (Deft) would be the best choice due to viscosity increase of Primer 5 (Spraylat) epoxy primer.

Polyurethane Primer 8 (Deft-QPL) dried in 4 hours, but had a viscosity greater than 100 seconds after 2 hours. Primer 7 (Courtaulds-QPL) took 6 hours to dry, but possessed a viscosity of 14 seconds after 2 hours. None tested meets the criteria of 4 hour dry time and 70 seconds after 2 hour pot-life.

60°F/20% RH – Epoxy Primer 3 (Dexter-modified) offered the relationship of dry time of 9 hours and viscosity of 25 seconds after 2 hours. Neither epoxy primer on the QPL was suitable due to rapid viscosity increase after 2 hour pot-life.

Polyurethane Primer 8 (Deft-QPL) dried in 13 hours, but reached a viscosity of 96 seconds after only 1 hour. No polyurethane primer tested was suitable.

60°F/80% RH – Epoxy Primer 4 (Sherwin-Williams-modified) exhibited a dry time of 6 ½ hours and viscosity of 47 seconds after 2 hours. Of the epoxy primers on the QPL, Primer 2 (Deft) would be the preferred choice.

Polyurethane Primer 7 (Courtaulds-QPL) dried in 5 hours and maintained a viscosity of 16 seconds after 2 hours. It would be the preferred choice.

90°F/20% RH – Epoxy Primer 5 (Spraylat-QPL) dried hard in 3 hours while maintaining a viscosity of 35 seconds after 2 hours, making it the first choice.

Polyurethane Primer 9 (Deft-modified) dried in 8 ½ hours, but was solid after 1 hour. No polyurethane primer would be suitable.

90°F/80% RH – Epoxy Primer 4 (Sherwin-Williams-modified) dried in 2 hours and possessed a viscosity of 48 seconds after 2 hours. Neither of the epoxy primers on the QPL tested possessed suitable viscosity stability after 2 hour pot-life.

Polyurethane Primer 7 (Courtaulds-QPL) dried in 2 ½ hours and retained a viscosity of 15 seconds after 2 hours. It would be the preferred choice.

The potential exists for primers to be formulated to achieve optimum application characteristics and performance under specific environmental conditions. The development of Purchase Descriptions or AMS Specifications for such materials would provide the US Air Force the opportunity to improve painting operations in those locations where environmental conditions vary significantly from the standard laboratory conditions under which primers are developed and qualified.

8.0 RECOMMENDATIONS

DISCLAIMER:

- **USAF does not endorse any one qualified product over another.**
- **Products evaluated were used under conditions for which they were not qualified.**
- **Painting is best accomplished in the middle of the range of discussed conditions.**

As observed, even during this limited testing, no primers performed the "best" under all environmental conditions. Properties of the wet paint and film characteristics varied between the primers and between the five environmental conditions. Each primer exhibited strengths and weaknesses.

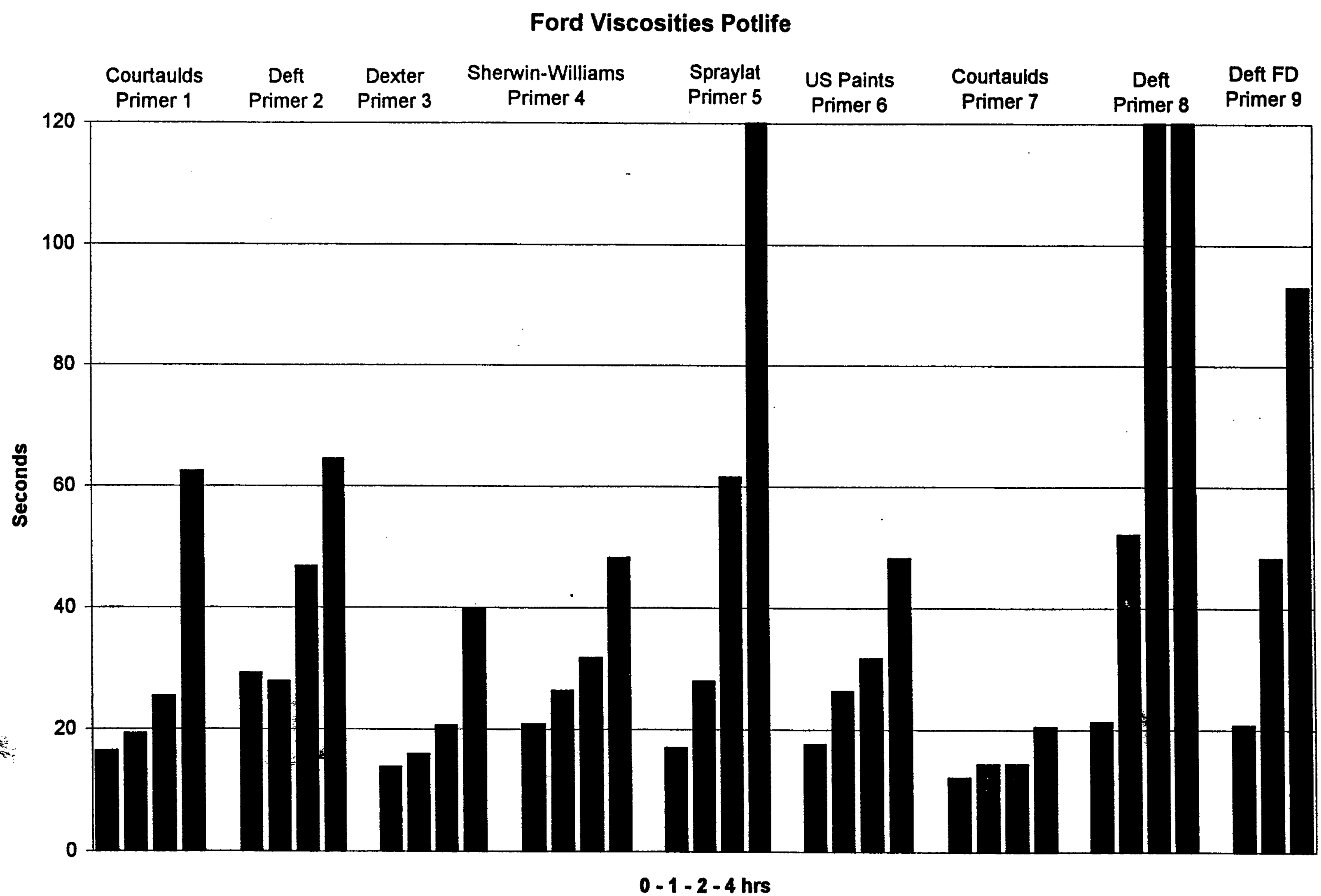
Dominant painting conditions dictate the benefit that would be derived from specific primers for specific environmental conditions. Purchase Descriptions for primers to be applied under specific environmental conditions could be developed by the USAF. Any such Purchase Descriptions would specify the environmental conditions and the drying and pot-life expected under those conditions as well as the same film performance requirements of the standard QPL specifications. Development of an AMS Specification would be another avenue that could be pursued.

Additional testing is needed to determine the optimum desired film properties and the wet properties of the primer under predominant painting conditions.

APPENDIX I

77 degrees F/50% RH

High Solids Primers

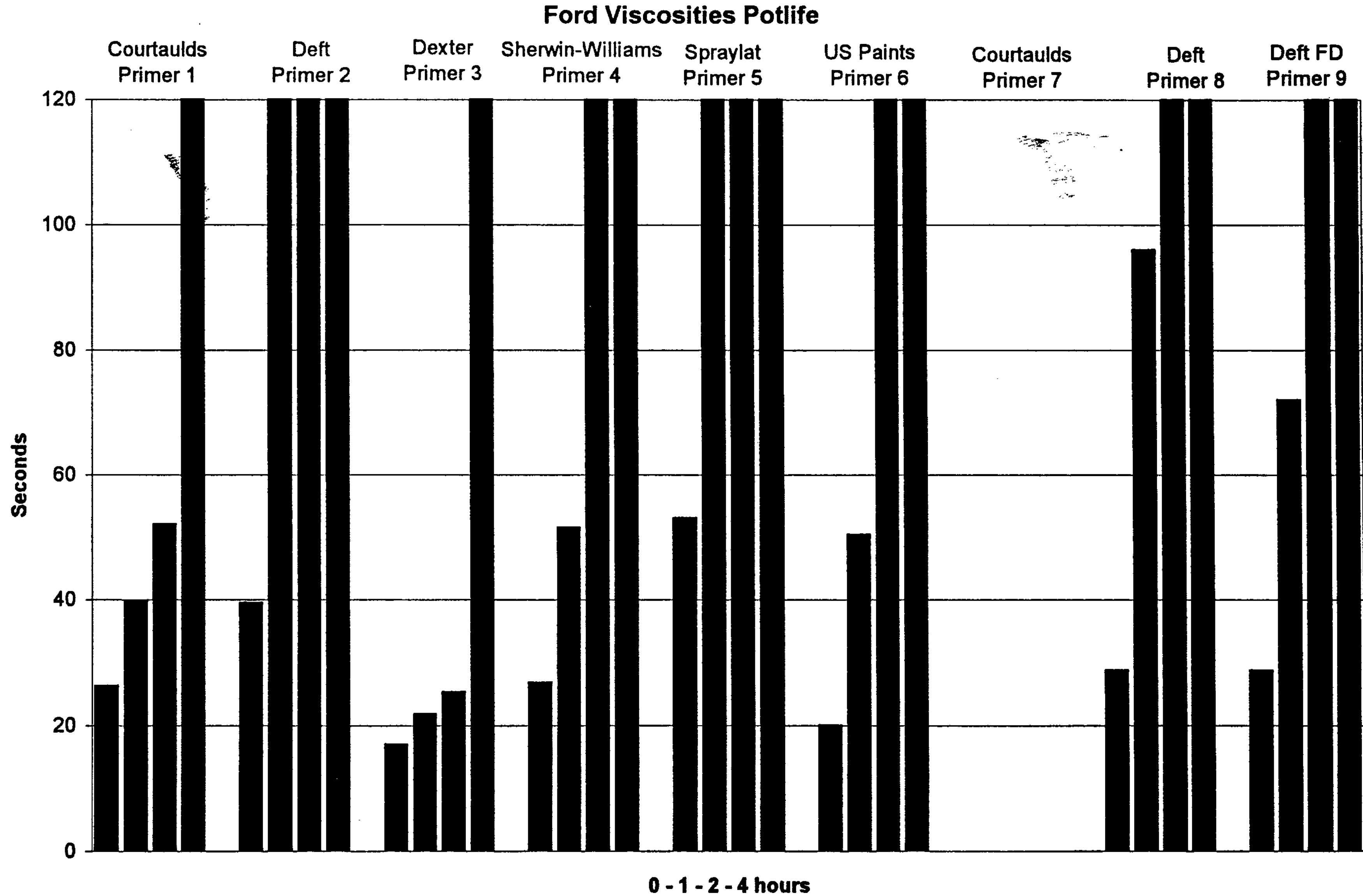


Ford #4 Viscosity

Appendix I

60 degrees F/20 % RH

High Solids Primers

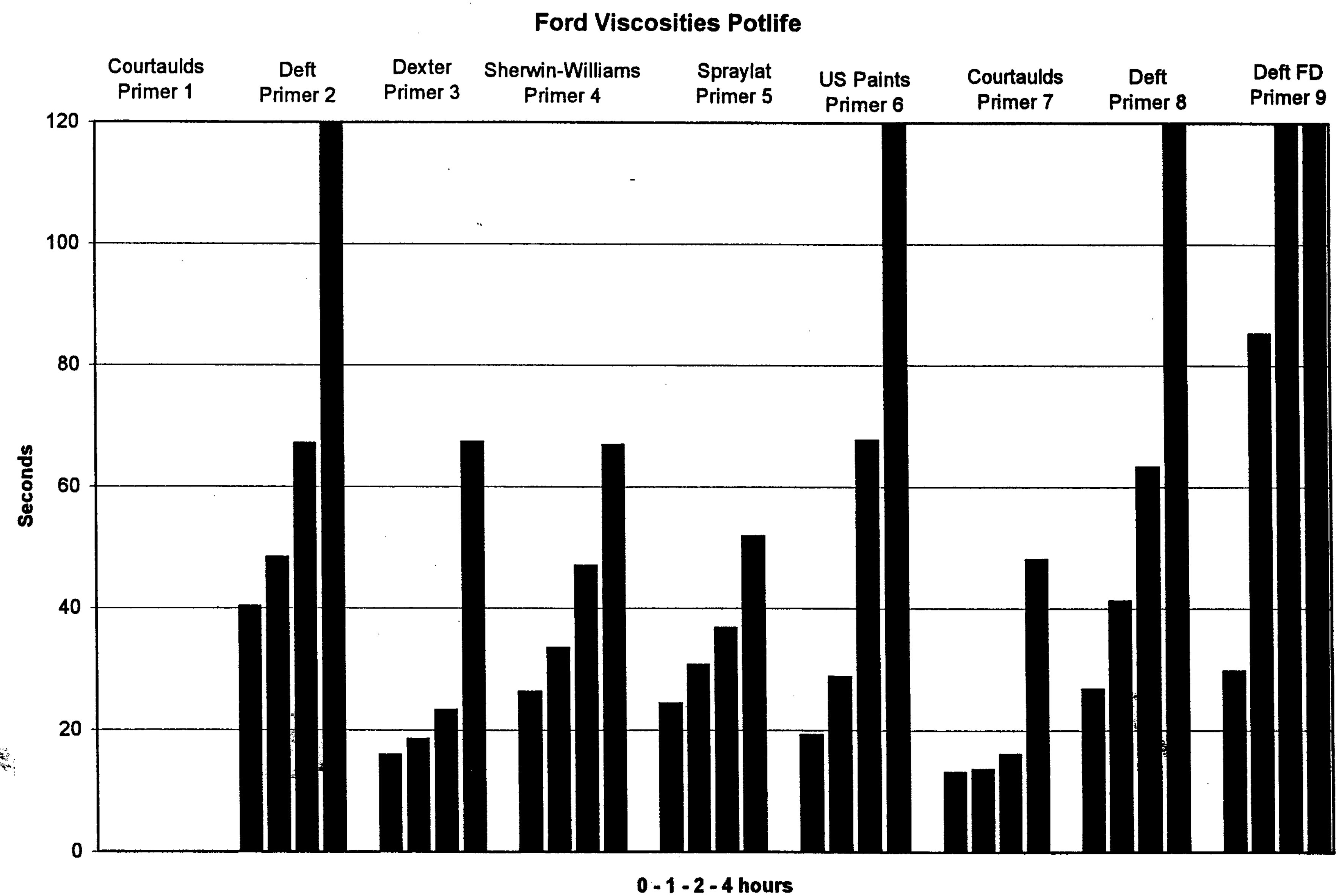


Ford #4 Viscosity

Appendix I

60 degrees F/80% RH

High Solids Primers

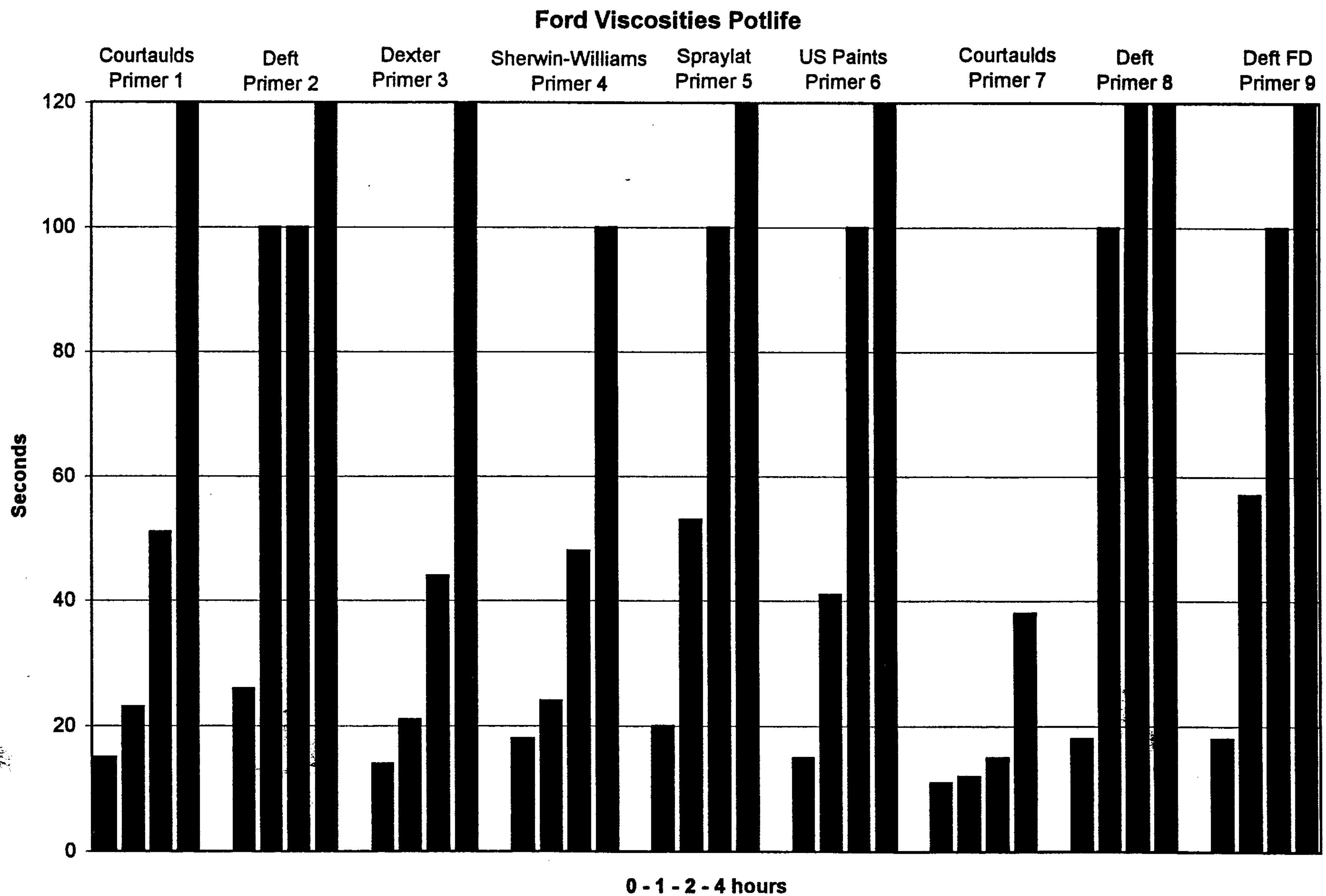


Ford #4 Viscosity

Appendix I

90 degrees F/80% RH

High Solids Primers

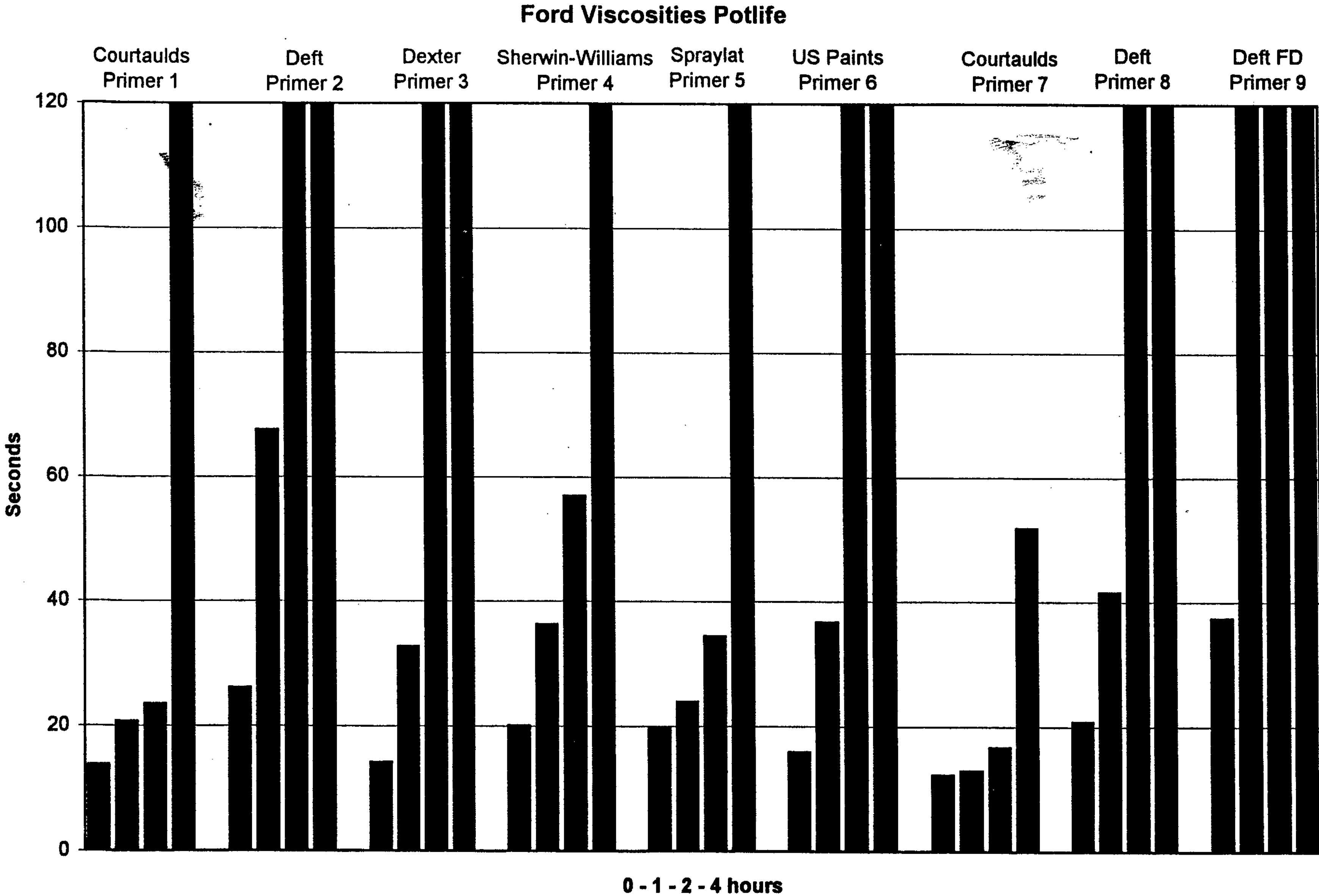


Ford #4 Viscosity

Appendix I

90 degrees F/20% RH

High Solids Primers



Ford #4 Viscosity

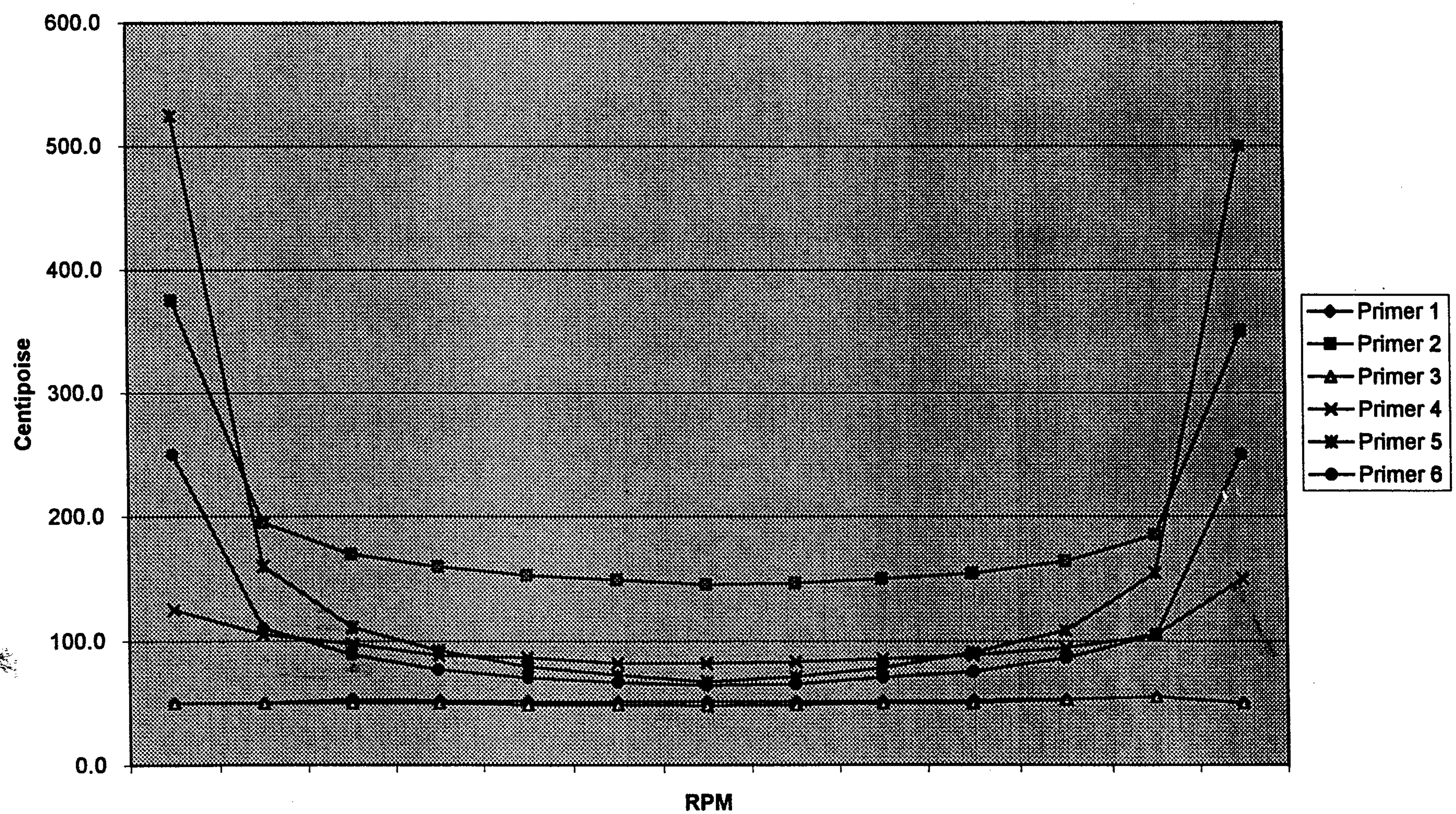
Appendix I

APPENDIX II

77 degrees F/50% RH

High Solids Primers

Brookfield
Epoxy Primers
Initial



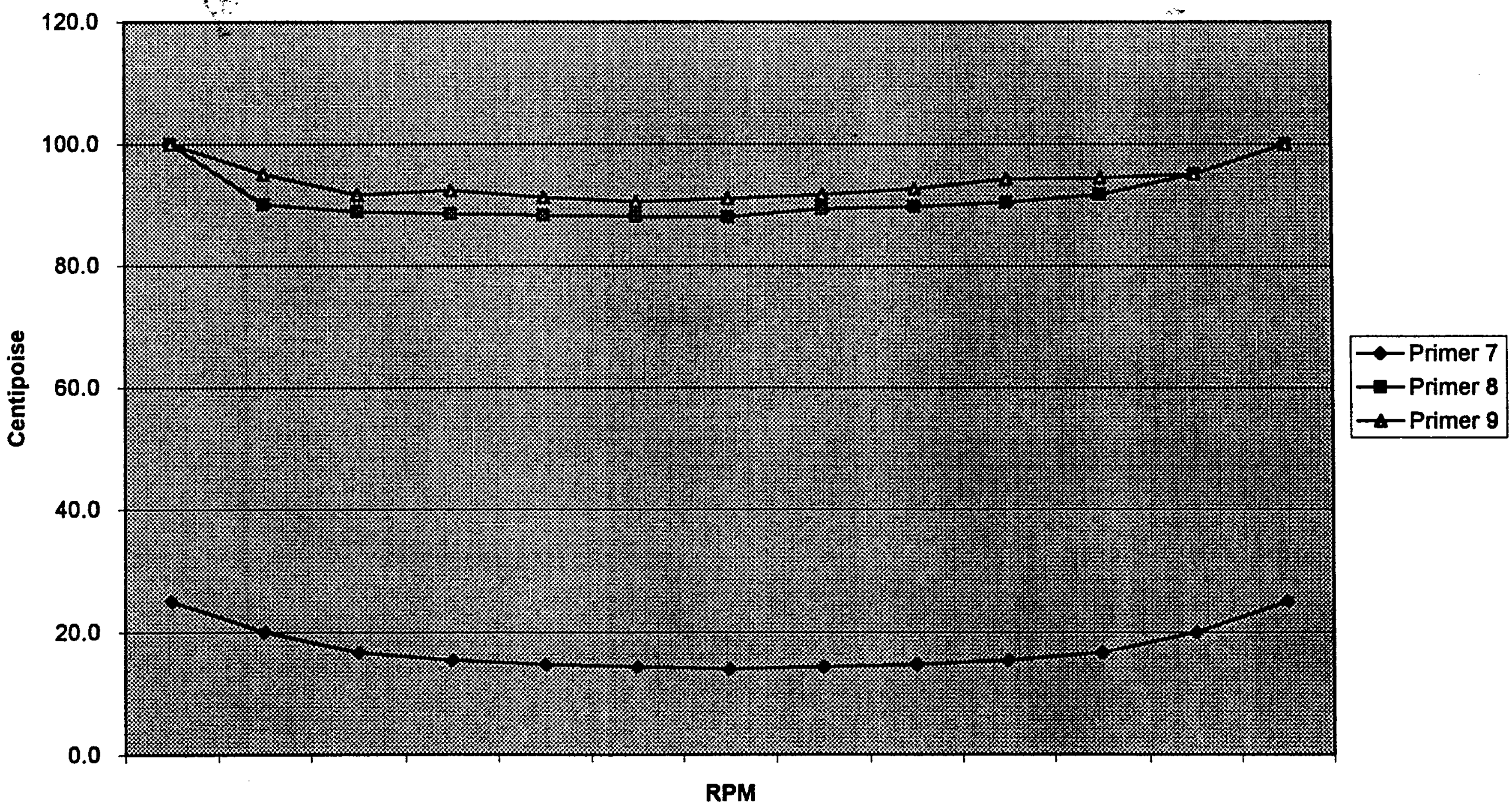
10 RPM to 250 RPM to 10 RPM

Appendix II

77 degrees F/50% RH

High Solids Primers

Brookfield
Polyurethane Primers
Initial



10 RPM to 250 RPM to 10 RPM

Appendix II

77 Degrees F/50% RH

High Solids Primers
Brookfield Viscosity

Speed RPM	Primer 1 initial Viscosity cP	1 hour Viscosity cP	2 hours Viscosity cP	4 hours Viscosity cP	Primer 2 initial Viscosity cP	1 hour Viscosity cP	2 hours Viscosity cP	4 hours Viscosity cP	Primer 3 initial Viscosity cP	1 hour Viscosity cP	2 hours Viscosity cP	4 hours Viscosity cP
10.0	50.0	75.0	125.0	375.0	375.0	375.0	450.0	3025.0	50.0	50.0	75.0	225.0
50.0	50.0	80.0	120.0	355.0	195.0	235.0	300.0	3025.0	50.0	60.0	95.0	230.0
90.0	52.8	77.8	122.2	358.3	169.4	222.2	280.6	2991.7	50.0	58.3	91.7	225.0
130.0	51.9	76.9	123.1	355.8	159.6	213.5	278.8	2755.8	50.0	57.7	90.4	226.9
170.0	51.5	79.4	123.5	352.9	152.9	210.3	276.5	2105.9	48.5	57.4	89.7	226.5
210.0	51.2	79.8	123.8	348.8	148.8	206.0	272.6	1607.1	48.8	57.1	89.3	227.4
250.0	51.0	79.0	123.0	345.0	145.0	202.0	272.0	1350.0	48.0	56.0	89.0	228.0
210.0	51.2	79.8	125.0	347.6	146.4	203.6	273.8	1607.1	48.8	58.3	90.5	229.8
170.0	51.5	79.4	125.0	351.5	150.0	205.9	276.5	2107.4	50.0	57.4	89.7	232.4
130.0	51.9	78.8	126.9	361.5	153.8	209.6	280.8	2755.8	50.0	59.6	92.3	234.6
90.0	52.8	80.6	125.0	372.2	163.9	216.7	286.1	3047.2	52.8	61.1	91.7	238.9
50.0	55.0	80.0	125.0	385.0	185.0	235.0	305.0	3070.0	55.0	60.0	95.0	240.0
10.0	50.0	75.0	125.0	425.0	350.0	375.0	475.0	3125.0	50.0	75.0	100.0	250.0

Speed RPM	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2
10.0	1.70	2.55	4.25	12.8	12.8	12.8	15.3	102.9	1.70	1.70	2.55	7.65
50.0	8.50	13.6	20.4	60.4	33.2	40.0	51.0	514.3	8.50	10.2	16.1	39.1
90.0	16.1	23.8	37.4	109.7	51.9	68.0	85.9	915.5	15.3	17.9	28.1	68.9
130.0	23.0	34.0	54.4	157.3	70.6	94.4	123.3	1218.1	22.1	25.5	40.0	100.3
170.0	29.8	45.9	71.4	204.0	88.4	121.6	159.8	1217.2	28.1	33.2	51.9	130.9
210.0	36.6	57.0	88.4	249.1	106.3	147.1	194.7	1147.5	34.8	40.8	63.8	162.4
250.0	43.4	67.2	104.6	293.3	123.3	171.7	231.2	1147.5	40.8	47.6	75.7	193.8
210.0	36.6	57.0	89.3	248.2	104.6	145.4	195.5	1147.5	34.8	41.7	64.6	164.1
170.0	29.8	45.9	72.3	203.2	86.7	119.0	159.8	1218.1	28.9	33.2	51.9	134.3
130.0	23.0	34.8	56.1	159.8	68.0	92.7	124.1	1218.1	22.1	26.4	40.8	103.7
90.0	16.1	24.7	38.3	113.9	50.2	66.3	87.6	932.5	16.1	18.7	28.1	73.1
50.0	9.35	13.6	21.3	65.4	31.5	40.0	51.9	521.9	9.35	10.2	16.1	40.8
10.0	1.70	2.55	4.25	14.5	11.9	12.8	16.1	106.3	1.70	2.55	3.40	8.50

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Appendix II

77 Degrees F/50% RH

High Solids Primers
Brookfield Viscosity

Speed RPM	Primer 4 initial Viscosity cP	1 hour Viscosity cP	2 hours Viscosity cP	4 hours Viscosity cP	Primer 5 initial Viscosity cP	1 hour Viscosity cP	2 hours Viscosity cP	Primer 6 initial Viscosity cP	1 hour Viscosity cP	2 hours Viscosity cP	4 hours Viscosity cP
10.0	125.0	225.0	350.0	550.0	525.0	850.0	1450.0	250.0	350.0	500.0	625.0
50.0	105.0	160.0	230.0	355.0	160.0	285.0	555.0	110.0	195.0	310.0	510.0
90.0	97.2	144.4	202.8	313.9	111.1	208.3	430.6	88.9	169.4	272.2	491.7
130.0	88.5	134.6	190.4	294.2	92.3	176.9	382.7	76.9	161.5	255.8	486.5
170.0	86.8	130.9	183.8	282.4	79.4	158.8	355.9	70.6	155.9	247.1	483.8
210.0	82.1	127.4	179.8	275.0	72.6	146.4	340.5	66.7	151.2	239.3	483.3
250.0	82.0	124.0	175.0	269.0	67.0	139.0	329.0	64.0	147.0	235.0	484.0
210.0	83.3	125.0	177.4	273.8	71.4	147.6	341.7	65.5	147.6	235.7	483.3
170.0	85.3	127.9	180.9	279.4	77.9	157.4	358.8	70.6	150.0	239.7	486.8
130.0	88.5	132.7	186.5	288.5	90.4	173.1	386.5	75.0	155.8	246.2	490.4
90.0	94.4	138.9	197.2	305.6	108.3	205.6	433.3	86.1	163.9	258.3	494.4
50.0	105.0	155.0	220.0	345.0	155.0	275.0	555.0	105.0	185.0	285.0	515.0
10.0	150.0	225.0	350.0	575.0	500.0	825.0	1475.0	250.0	325.0	475.0	625.0

Speed RPM	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2
10.0	4.25	7.65	11.9	18.7	17.9	28.9	49.3	8.50	11.9	17.0	21.3
50.0	17.9	27.2	39.1	60.4	27.2	48.5	94.4	18.7	33.2	52.7	86.7
90.0	29.8	44.2	62.1	96.1	34.0	63.8	131.8	27.2	51.9	83.3	150.5
130.0	39.1	59.5	84.2	130.1	40.8	78.2	169.1	34.0	71.4	113.1	215.1
170.0	50.2	75.7	106.3	163.2	45.9	91.8	205.7	40.8	90.1	142.8	279.7
210.0	58.7	91.0	128.4	196.4	51.9	104.6	243.1	47.6	108.0	170.9	345.1
250.0	69.7	105.4	148.8	228.7	57.0	118.2	279.7	54.4	125.0	199.8	411.4
210.0	59.5	89.3	126.7	195.5	51.0	105.4	244.0	46.8	105.4	168.3	345.1
170.0	49.3	73.9	104.6	161.5	45.1	91.0	207.4	40.8	86.7	138.6	281.4
130.0	39.1	58.7	82.4	127.5	40.0	76.5	170.9	33.2	68.9	108.8	216.8
90.0	28.9	42.5	60.4	93.5	33.2	62.9	132.6	26.4	50.2	79.1	151.3
50.0	17.9	26.4	37.4	58.7	26.4	46.8	94.4	17.9	31.5	48.5	87.6
10.0	5.10	7.65	11.9	19.5	17.0	28.1	50.2	8.50	11.1	16.1	21.3

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Appendix II

77 Degrees F/50% RH

High Solids Primers
Brookfield Viscosity

Speed RPM	Primer 7 initial Viscosity cP	1 hour Viscosity cP	2 hours Viscosity cP	4 hours Viscosity cP	Primer 8 initial Viscosity cP	1 hour Viscosity cP	2 hours Viscosity cP	4 hours Viscosity cP	Primer 9 initial Viscosity cP	1 hour Viscosity cP	2 hours Viscosity cP	4 hours Viscosity cP
10.0	25.0	-25.00	-25.00	25.0	100.0	225.0	700.0	4300.0	100.0	250.0	525.0	3025.0
50.0	20.0	15.0	25.0	65.0	90.0	265.0	750.0	4115.0	95.0	280.0	545.0	3025.0
90.0	16.7	16.7	27.8	66.7	88.9	269.4	747.2	3944.4	91.7	280.6	544.4	2991.7
130.0	15.4	17.3	26.9	67.3	88.5	271.2	748.1	2755.8	92.3	278.8	548.1	2755.8
170.0	14.7	16.2	26.5	67.6	88.2	272.1	744.1	1986.8	91.2	280.9	548.5	2105.9
210.0	14.3	17.9	28.6	67.9	88.1	273.8	740.5	1607.1	90.5	281.0	550.0	1607.1
250.0	14.0	17.0	27.0	68.0	88.0	274.0	739.0	1349.0	91.0	281.0	552.0	1350.0
210.0	14.3	17.9	27.4	67.9	89.3	275.0	744.0	1607.1	91.7	282.1	554.8	1607.1
170.0	14.7	17.6	26.5	67.6	89.7	276.5	750.0	1985.3	92.6	283.8	557.4	2107.4
130.0	15.4	17.3	26.9	69.2	90.4	276.9	753.8	2755.8	94.2	284.6	559.6	2755.8
90.0	16.7	16.7	27.8	66.7	91.7	277.8	758.3	3980.6	94.4	283.3	561.1	3047.2
50.0	20.0	10.0	20.0	65.0	95.0	280.0	760.0	4090.0	95.0	285.0	560.0	3070.0
10.0	25.0	-25.00	-25.00	25.0	100.0	250.0	725.0	4150.0	100.0	250.0	525.0	3125.0

Speed RPM	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2
10.0	0.85	-0.85	-0.85	0.85	3.40	7.65	23.8	146.2	3.40	8.50	17.9	102.9
50.0	3.40	2.55	4.25	11.1	15.3	45.1	127.5	699.6	16.1	47.6	92.7	514.3
90.0	5.10	5.10	8.50	20.4	27.2	82.4	228.7	1207.0	28.1	85.9	166.6	915.5
130.0	6.80	7.65	11.9	29.8	39.1	119.9	330.7	1218.1	40.8	123.3	242.3	1218.1
170.0	8.50	9.35	15.3	39.1	51.0	157.3	430.1	1148.4	52.7	162.4	317.0	1217.2
210.0	10.2	12.8	20.4	48.5	62.9	195.5	528.7	1147.5	64.6	200.6	392.7	1147.5
250.0	11.9	14.5	23.0	57.8	74.8	232.9	628.2	1146.7	77.4	238.9	469.2	1147.5
210.0	10.2	12.8	19.5	48.5	63.8	196.4	531.3	1147.5	65.4	201.5	396.1	1147.5
170.0	8.50	10.2	15.3	39.1	51.9	159.8	433.5	1147.5	53.6	164.1	322.2	1218.1
130.0	6.80	7.65	11.9	30.6	40.0	122.4	333.2	1218.1	41.7	125.8	247.4	1218.1
90.0	5.10	5.10	8.50	20.4	28.1	85.0	232.1	1218.1	28.9	86.7	171.7	932.5
50.0	3.40	1.70	3.40	11.1	16.1	47.6	129.2	695.3	16.1	48.5	95.2	521.9
10.0	0.85	-0.85	-0.85	0.85	3.40	8.50	24.7	141.1	3.40	8.50	17.9	106.3

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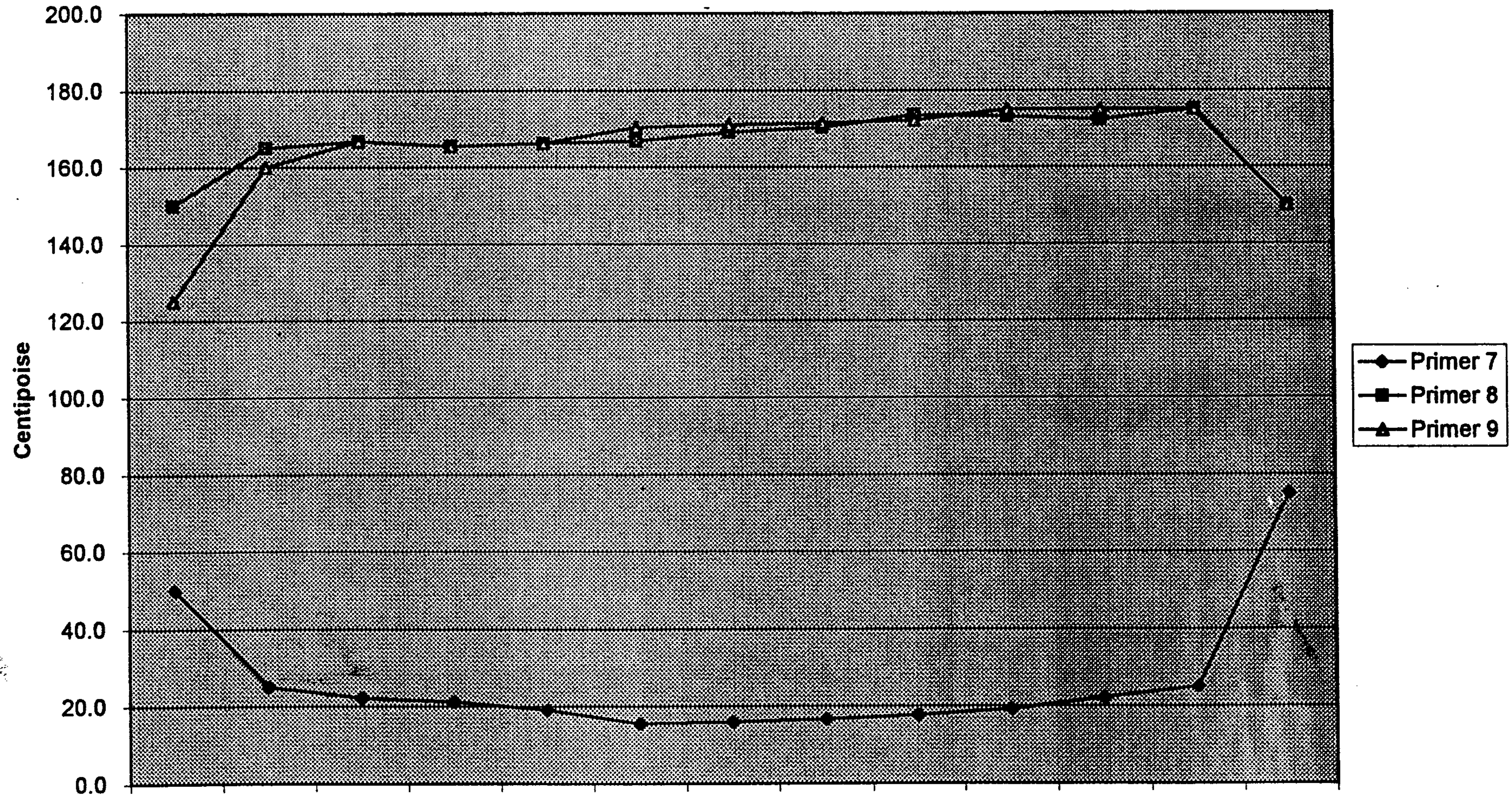
Appendix II

60 degrees F/20% RH

High Solids Primers

Brookfield
Polyurethane Primers
Initial



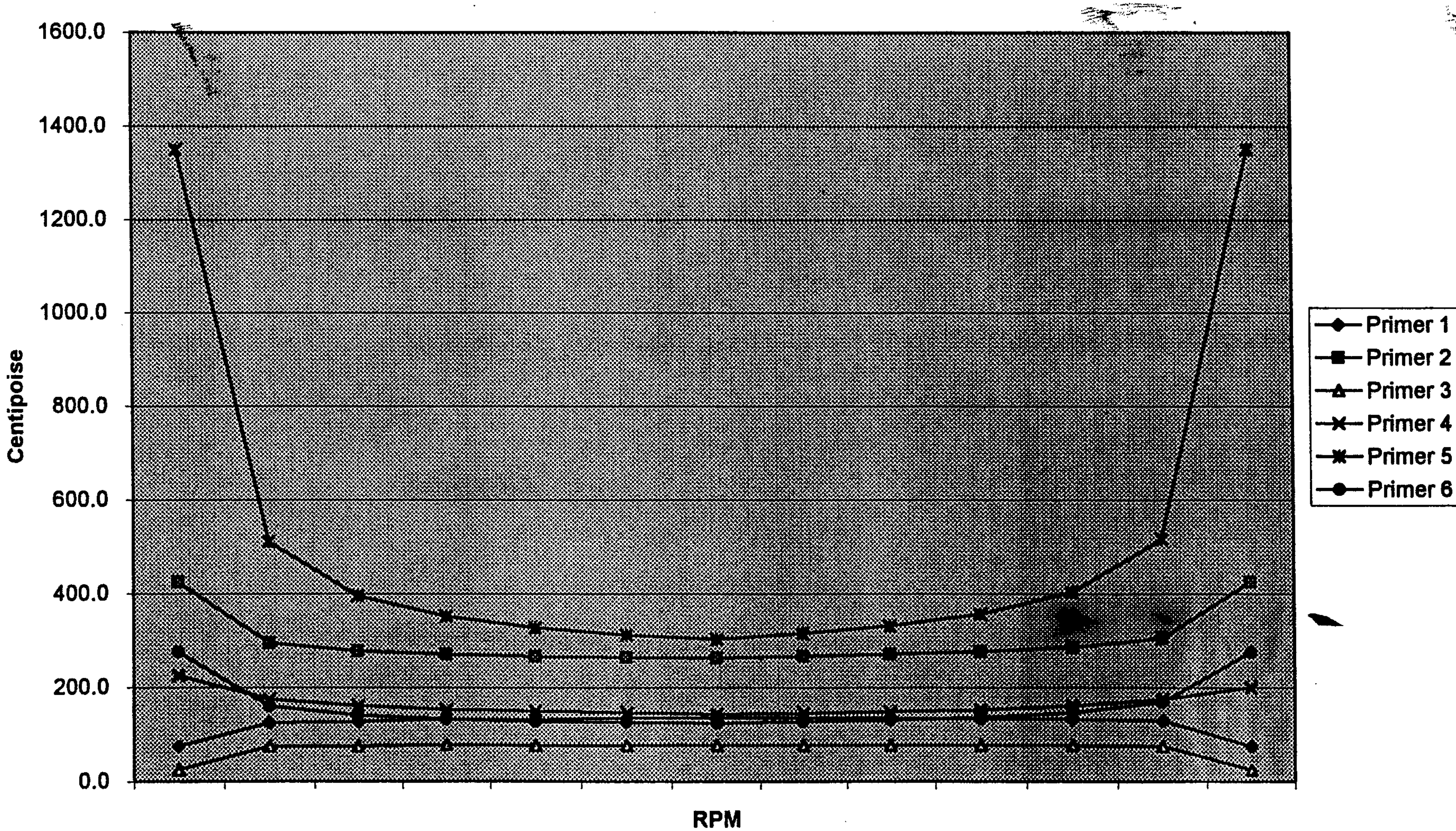
10 RPM to 250 RPM to 10 RPM

Appendix II

60 degrees F/20% RH

High Solids Primers

Brookfield
Epoxy Primers
Initial



10 RPM to 250 RPM to 10 RPM

Appendix II

60 degrees F/20% RH

High Solids Primers
Brookfield Viscosity

Speed RPM	Primer 1 initial Viscosity cP	1 hour Viscosity cP	2 hours Viscosity cP	4 hours Viscosity cP	Primer 2 initial Viscosity cP	1 hour Viscosity cP	2 hours Viscosity cP	4 hours Viscosity cP	Primer 3 initial Viscosity cP	1 hour Viscosity cP	2 hours Viscosity cP	4 hours Viscosity cP
10.0	75.0	125.0	200.0	475.0	425.0	500.0	575.0	1000.0	25.0	50.0	75.0	375.0
50.0	125.0	155.0	235.0	545.0	295.0	385.0	445.0	855.0	75.0	90.0	110.0	425.0
90.0	127.8	166.7	244.4	563.9	277.8	366.7	427.8	847.2	75.0	88.9	111.1	438.9
130.0	132.7	173.1	248.1	578.8	271.2	361.5	425.0	851.9	78.8	92.3	113.5	450.0
170.0	132.4	176.5	252.9	592.6	266.2	355.9	426.5	858.8	76.5	94.1	114.7	457.4
210.0	135.7	181.0	254.8	604.8	264.3	353.6	427.4	865.5	77.4	94.0	114.3	463.1
250.0	136.0	184.0	257.0	615.0	263.0	353.0	429.0	873.0	77.0	94.0	116.0	470.0
210.0	135.7	184.5	257.1	615.5	266.7	357.1	434.5	890.5	77.4	95.2	117.9	477.4
170.0	135.3	185.3	257.4	614.7	270.6	360.3	441.2	905.9	77.9	95.6	117.6	482.4
130.0	134.6	184.6	255.8	613.5	276.9	367.3	450.0	923.1	76.9	96.2	119.2	488.5
90.0	133.3	183.3	252.8	608.3	286.1	375.0	458.3	944.4	77.8	94.4	119.4	491.7
50.0	130.0	180.0	250.0	600.0	305.0	390.0	480.0	980.0	75.0	95.0	120.0	490.0
10.0	75.0	125.0	225.0	550.0	425.0	525.0	625.0	1200.0	25.0	50.0	75.0	450.0
Speed RPM	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2
10.0	2.55	4.25	6.80	16.1	14.5	17.0	19.5	34.0	0.85	1.70	2.55	12.8
50.0	21.3	26.4	40.0	92.7	50.2	65.4	75.7	145.4	12.8	15.3	18.7	72.3
90.0	39.1	51.0	74.8	172.6	85.0	112.2	130.9	259.3	23.0	27.2	34.0	134.3
130.0	58.7	76.5	109.7	255.9	119.9	159.8	187.9	376.6	34.8	40.8	50.2	198.9
170.0	76.5	102.0	146.2	342.6	153.9	205.7	246.5	496.4	44.2	54.4	66.3	264.4
210.0	96.9	129.2	181.9	431.8	188.7	252.5	305.2	618.0	55.3	67.2	81.6	330.7
250.0	115.6	156.4	218.5	522.8	223.6	300.0	364.7	742.1	65.4	79.9	98.6	399.5
210.0	96.9	131.8	183.6	439.5	190.4	255.0	310.3	635.8	55.3	68.0	84.2	340.9
170.0	78.2	107.1	148.8	355.3	156.4	208.3	255.0	523.6	45.1	55.3	68.0	278.8
130.0	59.5	81.6	113.1	271.1	122.4	162.4	198.9	408.0	34.0	42.5	52.7	215.9
90.0	40.8	56.1	77.4	186.2	87.6	114.8	140.3	289.0	23.8	28.9	36.6	150.5
50.0	22.1	30.6	42.5	102.0	51.9	66.3	81.6	166.6	12.8	16.1	20.4	83.3
10.0	2.55	4.25	7.65	18.7	14.5	17.9	21.3	40.8	0.85	1.70	2.55	15.3

Appendix II

60 degrees F/20% RH

High Solids Primers
Brookfield Viscosity

Speed RPM	Primer 4 initial Viscosity cP	1 hour Viscosity cP	2 hour Viscosity cP	4 hour Viscosity cP	Primer 5 initial Viscosity	1 hour Viscosity cP	2 hours Viscosity cP	Primer 6 initial Viscosity cP	1 hour Viscosity cP	2 hours Viscosity cP
10.0	225.0	350.0	575.0	1950.0	1350.0	2125.0	4675.0	275.0	625.0	1300.0
50.0	175.0	285.0	485.0	1620.0	510.0	875.0	2285.0	160.0	440.0	1010.0
90.0	161.1	269.4	461.1	1555.6	394.4	716.7	2019.4	141.7	411.1	980.6
130.0	153.8	263.5	450.0	1530.8	351.9	653.8	1928.8	132.7	400.0	982.7
170.0	150.0	258.8	442.6	1517.6	327.9	622.1	1882.4	127.9	394.1	992.6
210.0	146.4	257.1	438.1	1510.7	311.9	602.4	1703.6	126.2	391.7	1001.2
250.0	143.0	254.0	436.0	1431.0	303.0	591.0	1430.0	124.0	392.0	1011.0
210.0	145.2	257.1	439.3	1515.5	315.5	608.3	1703.6	127.4	396.4	1022.6
170.0	148.5	260.3	442.6	1525.0	330.9	630.9	1905.9	130.9	402.9	1033.8
130.0	151.9	265.4	448.1	1542.3	355.8	665.4	1967.3	136.5	411.5	1046.2
90.0	161.1	275.0	461.1	1569.4	402.8	725.0	2080.6	147.2	425.0	1061.1
50.0	175.0	295.0	490.0	1640.0	515.0	880.0	2375.0	170.0	460.0	1095.0
10.0	200.0	350.0	625.0	2000.0	1350.0	2125.0	4750.0	275.0	650.0	1300.0

Speed RPM	Shear Stress D/Cm2	D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2
10.0	7.65	11.9	19.5	66.3	45.9	72.3	159.0	9.35	21.3	44.2
50.0	29.8	48.5	82.4	275.4	86.7	148.8	388.5	27.2	74.8	171.7
90.0	49.3	82.4	141.1	476.0	120.7	219.3	618.0	43.4	125.8	300.0
130.0	68.0	116.5	198.9	676.6	155.6	289.0	852.6	58.7	176.8	434.4
170.0	86.7	149.6	255.9	877.2	189.6	359.6	1088.0	73.9	227.8	573.8
210.0	104.6	183.6	312.8	1078.7	222.7	430.1	1216.4	90.1	279.7	714.9
250.0	121.6	215.9	370.6	1216.4	257.5	502.4	1215.5	105.4	333.2	859.4
210.0	103.7	183.6	313.7	1082.1	225.3	434.4	1216.4	91.0	283.0	730.2
170.0	85.9	150.5	255.9	881.5	191.3	364.7	1101.6	75.7	232.9	597.6
130.0	67.2	117.3	198.1	681.7	157.3	294.1	869.6	60.4	181.9	462.4
90.0	49.3	84.2	141.1	480.3	123.3	221.9	636.7	45.1	130.1	324.7
50.0	29.8	50.2	83.3	278.8	87.6	149.6	403.8	28.9	78.2	186.2
10.0	6.80	11.9	21.3	68.0	45.9	72.3	161.5	9.35	22.1	44.2

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Appendix II

60 degrees F/20% RH

High Solids Primers
Brookfield Viscosity

Speed RPM	Primer 7 initial Viscosity cP	1 hour Viscosity cP	2 hours Viscosity cP	4 hours Viscosity cP	Primer 8 initial Viscosity cP	1 hour Viscosity cP	2 hours Viscosity cP	Primer 9 initial Viscosity cP	1 hour Viscosity cP	2 hours Viscosity cP	Speed RPM
10.0	50.0	50.0	50.0	50.0	150.0	475.0	1450.0	125.0	375.0	650.0	10.0
50.0	25.0	25.0	30.0	35.0	165.0	500.0	1490.0	160.0	410.0	680.0	50.0
90.0	22.2	22.2	25.0	33.3	166.7	505.6	1497.2	166.7	413.9	691.7	90.0
130.0	21.2	19.2	21.2	30.8	165.4	511.5	1500.0	165.4	417.3	701.9	130.0
170.0	19.1	17.6	20.6	29.4	166.2	511.8	1504.4	166.2	422.1	708.8	170.0
210.0	15.5	19.0	16.7	28.6	166.7	511.9	1507.1	170.2	422.6	715.5	210.0
250.0	16.0	17.0	16.0	27.0	169.0	513.0	1431.0	171.0	426.0	721.0	250.0
210.0	16.7	17.9	23.8	28.6	170.2	520.2	1523.8	171.4	428.6	727.4	210.0
170.0	17.6	19.1	20.6	29.4	173.5	525.0	1541.2	172.1	432.4	732.4	170.0
130.0	19.2	19.2	21.2	28.8	173.1	530.8	1557.7	175.0	434.6	738.5	130.0
90.0	22.2	22.2	25.0	30.6	172.2	533.3	1572.2	175.0	436.1	741.7	90.0
50.0	25.0	20.0	25.0	35.0	175.0	535.0	1585.0	175.0	435.0	745.0	50.0
10.0	75.0	50.0	25.0	50.0	150.0	525.0	1575.0	150.0	425.0	725.0	10.0

Speed RPM	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Speed RPM
10.0	1.70	1.70	1.70	1.70	5.10	16.1	49.3	4.25	12.8	22.1	10.0
50.0	4.25	4.25	5.10	5.95	28.1	85.0	253.3	27.2	69.7	115.6	50.0
90.0	6.80	6.80	7.65	10.2	51.0	154.7	458.2	51.0	126.7	211.7	90.0
130.0	9.35	8.50	9.35	13.6	73.1	226.1	663.0	73.1	184.5	310.3	130.0
170.0	11.1	10.2	11.9	17.0	96.1	295.8	869.6	96.1	244.0	409.7	170.0
210.0	11.1	13.6	11.9	20.4	119.0	365.5	1076.1	121.6	301.8	510.9	210.0
250.0	13.6	14.5	13.6	23.0	143.6	436.1	1216.4	145.4	362.1	612.8	250.0
210.0	11.9	12.8	17.0	20.4	121.6	371.5	1088.0	122.4	306.0	519.3	210.0
170.0	10.2	11.1	11.9	17.0	100.3	303.5	890.8	99.5	249.9	423.3	170.0
130.0	8.50	8.50	9.35	12.8	76.5	234.6	688.5	77.4	192.1	326.4	130.0
90.0	6.80	6.80	7.65	9.35	52.7	163.2	481.1	53.6	133.4	227.0	90.0
50.0	4.25	3.40	4.25	5.95	29.8	91.0	269.5	29.8	73.9	126.7	50.0
10.0	2.55	1.70	0.85	1.70	5.10	17.9	53.6	5.10	14.5	24.7	10.0

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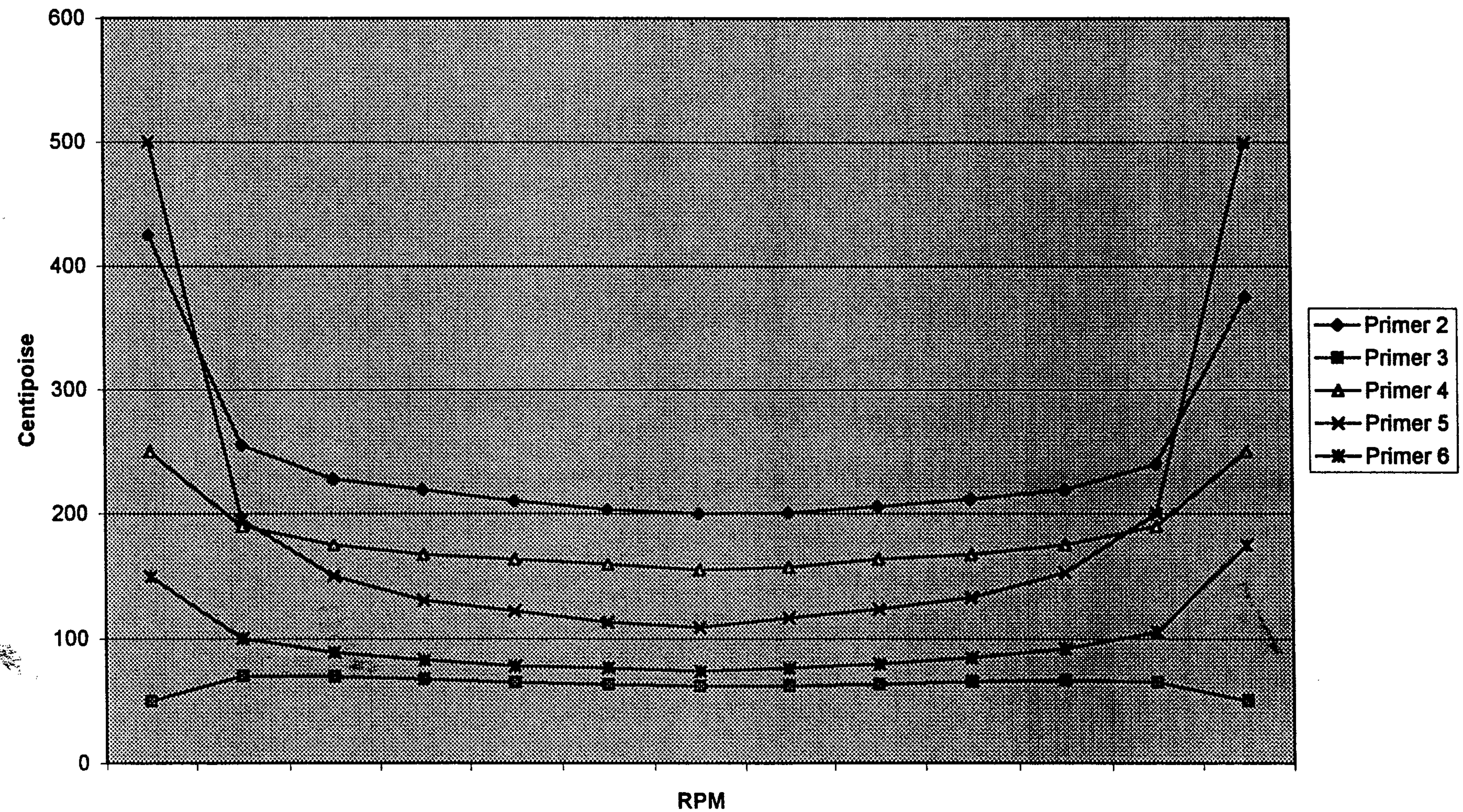
Appendix II

60 degrees F/80% RH

High Solids Primers

Brookfield
Epoxy Primers
Initial

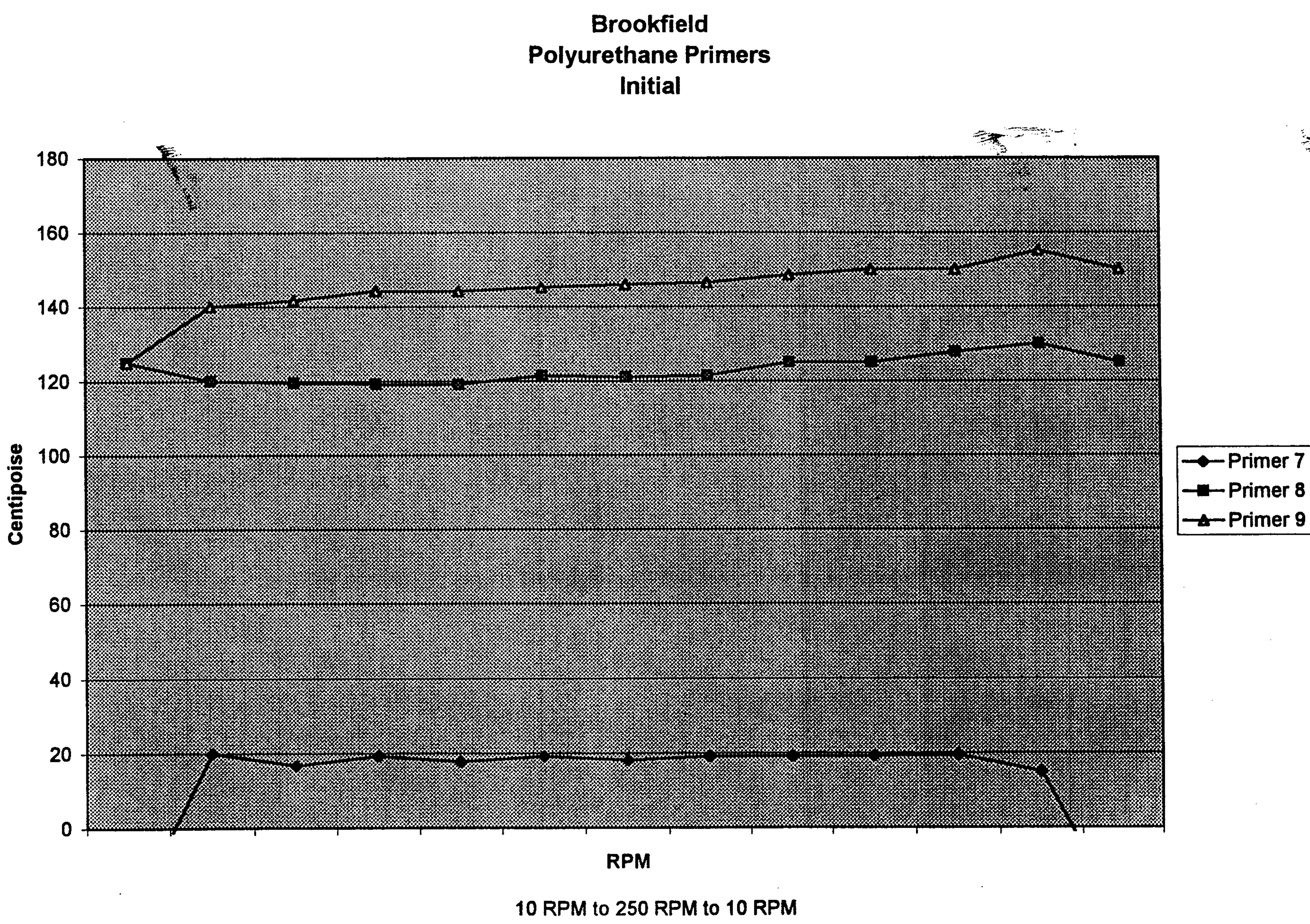


10 RPM to 250 RPM to 10 RPM

Appendix II

60 degrees F/80% RH

High Solids Primers



Appendix II

Speed RPM	Primer 2 initial Viscosity cP	1 hour Viscosity cP	2 hours Viscosity cP	4 hours Viscosity cP	Primer 3 initial Viscosity cP	1 hour Viscosity cP	2 hours Viscosity cP	4 hours Viscosity cP
10.0	425.0	375.0	425.0	550.0	50.0	50.0	50.0	275.0
50.0	255.0	260.0	310.0	475.0	70.0	75.0	90.0	345.0
90.0	227.8	238.9	300.0	475.0	69.4	72.2	97.2	358.3
130.0	219.2	236.5	301.9	480.8	67.3	75.0	98.1	367.3
170.0	210.3	233.8	302.9	488.2	64.7	75.0	101.5	375.0
210.0	203.6	234.5	306.0	494.0	63.1	75.0	101.2	382.1
250.0	200.0	234.0	309.0	500.0	62.0	75.0	101.0	388.0
210.0	201.2	239.3	316.7	508.3	61.9	75.0	103.6	392.9
170.0	205.9	242.6	320.6	519.1	63.2	76.5	104.4	397.1
130.0	211.5	250.0	326.9	528.8	65.4	76.9	103.8	401.9
90.0	219.4	258.3	336.1	538.9	66.7	77.8	102.8	400.0
50.0	240.0	280.0	355.0	560.0	65.0	80.0	100.0	400.0
10.0	375.0	400.0	475.0	675.0	50.0	25.0	75.0	375.0

Speed RPM	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2
10.0	14.5	12.8	14.5	18.7	1.70	1.70	1.70	9.35
50.0	43.4	44.2	52.7	80.8	11.9	12.8	15.3	58.7
90.0	69.7	73.1	91.8	145.4	21.3	22.1	29.8	109.7
130.0	96.9	104.6	133.4	212.5	29.8	33.2	43.4	162.4
170.0	121.6	135.1	175.1	282.2	37.4	43.4	58.7	216.8
210.0	145.4	167.5	218.5	352.8	45.1	53.6	72.3	272.9
250.0	170.0	198.9	262.6	425.0	52.7	63.8	85.9	329.8
210.0	143.6	170.9	226.1	363.0	44.2	53.6	73.9	280.5
170.0	119.0	140.3	185.3	300.0	36.6	44.2	60.4	229.5
130.0	93.5	110.5	144.5	233.8	28.9	34.0	45.9	177.7
90.0	67.2	79.1	102.9	164.9	20.4	23.8	31.5	122.4
50.0	40.8	47.6	60.4	95.2	11.1	13.6	17.0	68.0
10.0	12.8	13.6	16.1	23.0	1.70	0.85	2.55	12.8

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Speed RPM	Primer 4 initial Viscosity cP	1 hour Viscosity cP	2 hours Viscosity cP	4 hours Viscosity cP	Primer 5 intial Viscosity cP	1 hour Viscosity cP	2 hours Viscosity cP	4 hours Viscosity cP	Primer 6 initial Viscosity cP	1 hour Viscosity cP	2 hours Viscosity cP	4 hours Viscosity cP
10.0	250.0	225.0	325.0	450.0	500.0	600.0	675.0	750.0	150.0	300.0	475.0	1950.0
50.0	190.0	195.0	270.0	385.0	195.0	240.0	280.0	350.0	100.0	180.0	380.0	2000.0
90.0	175.0	180.6	258.3	372.2	150.0	188.9	227.8	288.9	88.9	158.3	366.7	2063.9
130.0	167.3	176.9	251.9	363.5	130.8	167.3	205.8	263.5	82.7	150.0	361.5	2121.2
170.0	163.2	173.5	250.0	361.8	122.1	157.4	192.6	250.0	77.9	147.1	361.8	2105.9
210.0	159.5	172.6	248.8	361.9	113.1	148.8	184.5	239.3	76.2	144.0	363.1	1703.6
250.0	155.0	171.0	247.0	361.0	109.0	142.0	179.0	232.0	74.0	142.0	364.0	1358.0
210.0	157.1	172.6	250.0	365.5	116.7	147.6	186.9	239.3	76.2	145.2	366.7	1703.6
170.0	163.2	176.5	254.4	370.6	123.5	155.9	197.1	248.5	79.4	148.5	370.6	2105.9
130.0	167.3	182.7	259.6	378.8	132.7	169.2	211.5	265.4	84.6	153.8	376.9	2294.2
90.0	175.0	188.9	269.4	388.9	152.8	191.7	236.1	288.9	91.7	161.1	386.1	2291.7
50.0	190.0	200.0	290.0	415.0	200.0	240.0	290.0	350.0	105.0	180.0	405.0	2285.0
10.0	250.0	250.0	350.0	500.0	500.0	600.0	675.0	750.0	175.0	275.0	475.0	2300.0

Speed RPM	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2
10.0	8.50	7.65	11.1	15.3	17.0	20.4	23.0	25.5	5.10	10.2	16.1	66.3
50.0	32.3	33.2	45.9	65.4	33.2	40.8	47.6	59.5	17.0	30.6	64.6	340.0
90.0	53.6	55.3	79.1	113.9	45.9	57.8	69.7	88.4	27.2	48.5	112.2	631.6
130.0	73.9	78.2	111.4	160.6	57.8	73.9	91.0	116.5	36.6	66.3	159.8	937.6
170.0	94.4	100.3	144.5	209.1	70.6	91.0	111.4	144.5	45.1	85.0	209.1	1217.2
210.0	113.9	123.3	177.7	258.4	80.8	106.3	131.8	170.9	54.4	102.9	259.3	1216.4
250.0	131.8	145.4	210.0	306.9	92.7	120.7	152.1	197.2	62.9	120.7	309.4	1154.3
210.0	112.2	123.3	178.5	261.0	83.3	105.4	133.4	170.9	54.4	103.7	261.8	1216.4
170.0	94.4	102.0	147.1	214.2	71.4	90.1	113.9	143.6	45.9	85.9	214.2	1217.2
130.0	73.9	80.8	114.8	167.5	58.7	74.8	93.5	117.3	37.4	68.0	166.6	1014.1
90.0	53.6	57.8	82.4	119.0	46.8	58.7	72.3	88.4	28.1	49.3	118.2	701.3
50.0	32.3	34.0	49.3	70.6	34.0	40.8	49.3	59.5	17.9	30.6	68.9	388.5
10.0	8.50	8.50	11.9	17.0	17.0	20.4	23.0	25.5	5.95	9.35	16.1	78.2

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Speed RPM	Primer 7 initial Viscosity cP	1 hour Viscosity cP	4 hours Viscosity cP	Speed RPM	Primer 8 initial Viscosity cP	1 hour Viscosity cP	2 hours Viscosity cP	4 hours Viscosity cP	Primer 9 initial Viscosity cP	1 hour Viscosity cP
10.0	-25.00	0.00	725.0	10.0	125.0	150.0	225.0	500.0	125.0	375.0
50.0	20.0	25.0	525.0	50.0	120.0	160.0	260.0	535.0	140.0	375.0
90.0	16.7	25.0	480.6	90.0	119.4	166.7	263.9	541.7	141.7	375.0
130.0	19.2	25.0	453.8	130.0	119.2	169.2	269.2	550.0	144.2	375.0
170.0	17.6	26.5	433.8	170.0	119.1	170.6	273.5	557.4	144.1	377.9
210.0	19.0	23.8	421.4	210.0	121.4	172.6	279.8	564.3	145.2	379.8
250.0	18.0	26.0	411.0	250.0	121.0	176.0	284.0	571.0	146.0	383.0
210.0	19.0	27.4	420.2	210.0	121.4	178.6	288.1	577.4	146.4	388.1
170.0	19.1	26.5	430.9	170.0	125.0	179.4	291.2	583.8	148.5	389.7
130.0	19.2	26.9	448.1	130.0	125.0	182.7	294.2	590.4	150.0	394.2
90.0	19.4	27.8	472.2	90.0	127.8	183.3	294.4	594.4	150.0	397.2
50.0	15.0	25.0	505.0	50.0	130.0	185.0	300.0	600.0	155.0	400.0
10.0	-25.00	0.00	625.0	10.0	125.0	175.0	275.0	600.0	150.0	400.0

Speed RPM	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Speed RPM	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2
10.0	-0.85	0.00	24.7	10.0	4.25	5.10	7.65	17.0	4.25	12.8
50.0	3.40	4.25	89.3	50.0	20.4	27.2	44.2	91.0	23.8	63.8
90.0	5.10	7.65	147.1	90.0	36.6	51.0	80.8	165.8	43.4	114.8
130.0	8.50	11.1	200.6	130.0	52.7	74.8	119.0	243.1	63.8	165.8
170.0	10.2	15.3	250.8	170.0	68.9	98.6	158.1	322.2	83.3	218.5
210.0	13.6	17.0	300.9	210.0	86.7	123.3	199.8	402.9	103.7	271.1
250.0	15.3	22.1	349.4	250.0	102.9	149.6	241.4	485.4	124.1	325.5
210.0	13.6	19.5	300.0	210.0	86.7	127.5	205.7	412.3	104.6	277.1
170.0	11.1	15.3	249.1	170.0	72.3	103.7	168.3	337.5	85.9	225.3
130.0	8.50	11.9	198.1	130.0	55.3	80.8	130.1	261.0	66.3	174.3
90.0	5.95	8.50	144.5	90.0	39.1	56.1	90.1	181.9	45.9	121.6
50.0	2.55	4.25	85.9	50.0	22.1	31.5	51.0	102.0	26.4	68.0
10.0	-0.85	0.00	21.3	10.0	4.25	5.95	9.35	20.4	5.10	13.6
					4.25					

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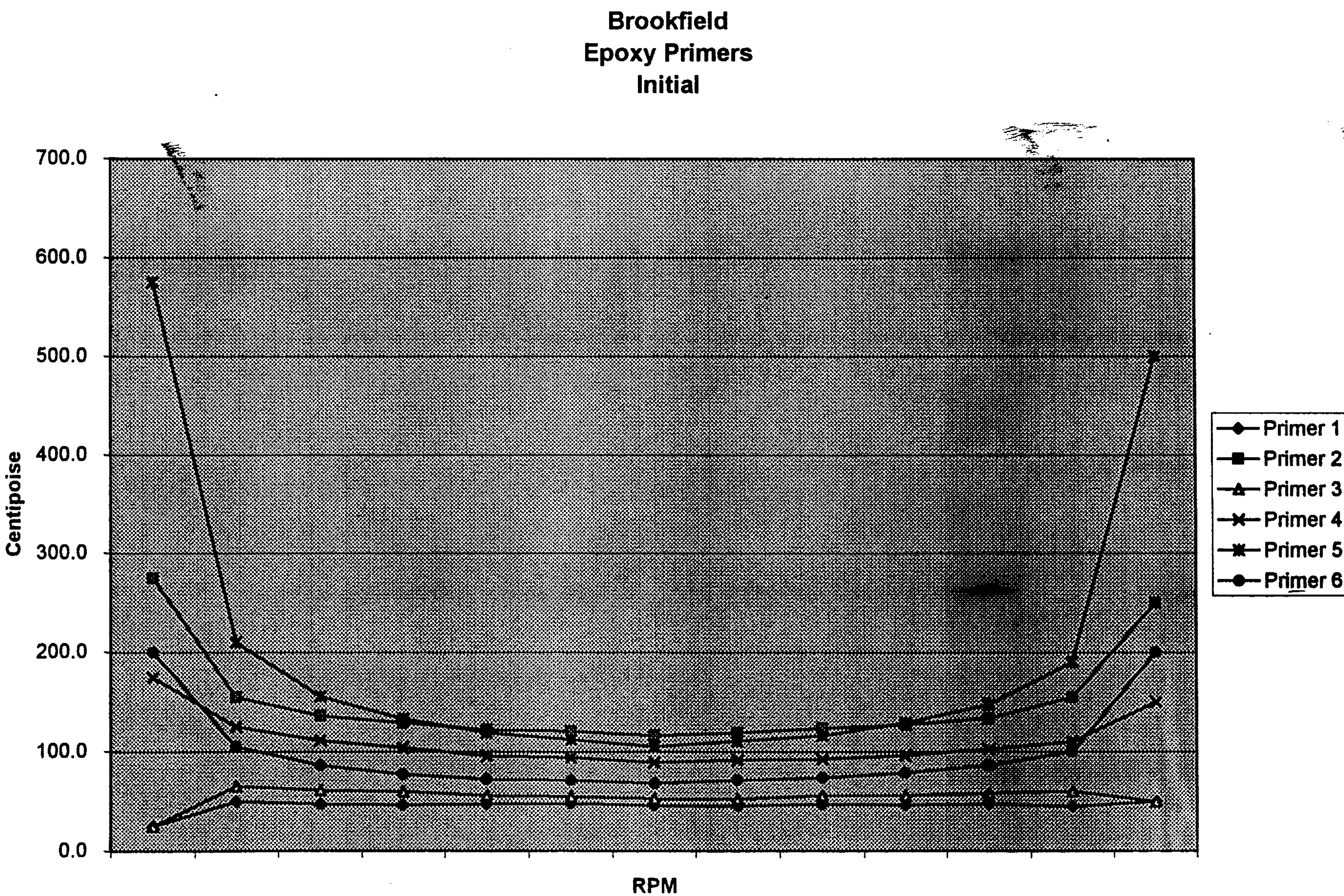
90 degrees F/20% RH

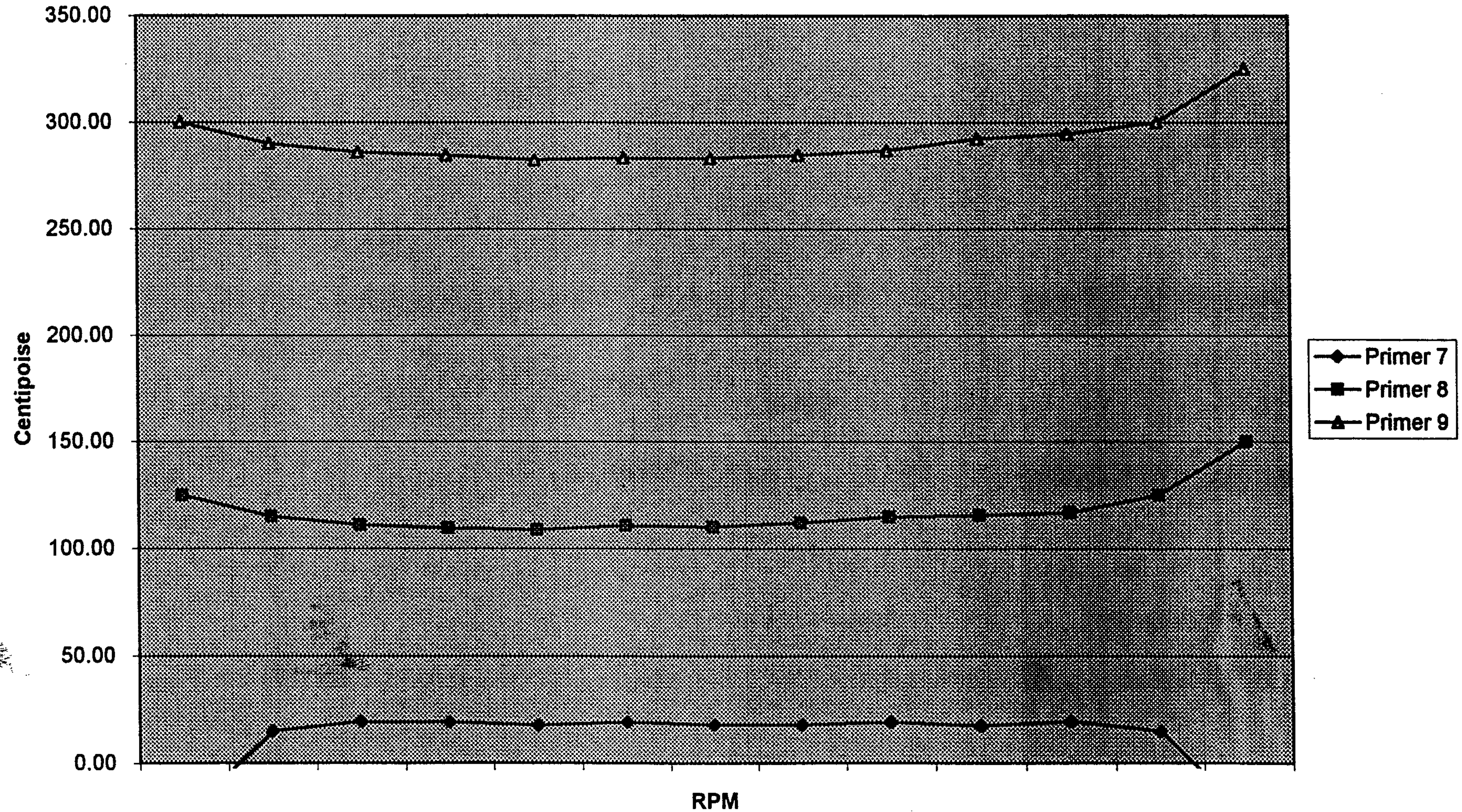
High Solids Primers



10 RPM to 250 RPM to 10 RPM

Appendix II

Brookfield
Polyurethane Primers
Initial



10 RPM to 250 RPM to 10 RPM

Appendix II

90 degrees F/20% RH

High Solids Primers
Brookfield Viscosity

Speed RPM	Primer 1 initial Viscosity cP	Primer 1 1 hour Viscosity cP	Primer 1 2 hours Viscosity cP	Primer 1 4 hours Viscosity cP	Primer 2 initial Viscosity cP	Primer 2 1 hour Viscosity cP	Primer 2 2 hours Viscosity cP	Primer 3 initial Viscosity cP	Primer 3 1 hour Viscosity cP
10.0	25.0	50.0	50.0	875.0	275.0	575.0	1400.0	25.0	175.0
50.0	50.0	45.0	75.0	885.0	155.0	415.0	1165.0	65.0	200.0
90.0	47.2	44.4	72.2	883.3	136.1	388.9	1125.0	61.1	194.4
130.0	46.2	44.2	71.2	867.3	128.8	373.1	1101.9	59.6	190.4
170.0	47.1	42.6	70.6	844.1	122.1	358.8	1082.4	55.9	186.8
210.0	47.6	39.3	71.4	821.4	120.2	350.0	1066.7	54.8	182.1
250.0	46.0	41.0	70.0	802.0	116.0	345.0	1057.0	53.0	179.0
210.0	45.2	44.0	70.2	806.0	119.0	344.0	1065.5	52.4	176.2
170.0	47.1	42.6	70.6	817.6	123.5	345.6	1072.1	55.9	179.4
130.0	46.2	42.3	71.2	840.4	126.9	350.0	1084.6	55.8	176.9
90.0	47.2	44.4	72.2	872.2	133.3	358.3	1105.6	58.3	180.6
50.0	45.0	45.0	75.0	925.0	155.0	375.0	1145.0	60.0	180.0
10.0	50.0	75.0	75.0	1025.0	250.0	525.0	1425.0	50.0	150.0

Speed RPM	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2
10.0	0.85	1.70	1.70	29.8	9.35	19.5	47.6	0.85	5.95
50.0	8.50	7.65	12.8	150.5	26.4	70.6	198.1	11.1	34.0
90.0	14.5	13.6	22.1	270.3	41.7	119.0	344.3	18.7	59.5
130.0	20.4	19.5	31.5	383.4	57.0	164.9	487.1	26.4	84.2
170.0	27.2	24.7	40.8	487.9	70.6	207.4	625.6	32.3	108.0
210.0	34.0	28.1	51.0	586.5	85.9	249.9	761.6	39.1	130.1
250.0	39.1	34.8	59.5	681.7	98.6	293.3	898.5	45.1	152.1
210.0	32.3	31.5	50.2	575.5	85.0	245.7	760.8	37.4	125.8
170.0	27.2	24.7	40.8	472.6	71.4	199.8	619.7	32.3	103.7
130.0	20.4	18.7	31.5	371.5	56.1	154.7	479.4	24.7	78.2
90.0	14.5	13.6	22.1	266.9	40.8	109.7	338.3	17.9	55.3
50.0	7.65	7.65	12.8	157.3	26.4	63.8	194.7	10.2	30.6
10.0	1.70	2.55	2.55	34.8	8.50	17.9	48.5	1.70	5.10

Appendix II

90 degrees F/20% RH

High Solids Primers
Brookfield Viscosity

Speed RPM	Primer 4 initial Viscosity cP	1 hour Viscosity cP	2 hours Viscosity cP	4 hours Viscosity cP	Primer 5 initial Viscosity cP	1 hour Viscosity cP	2 hours Viscosity cP	4 hours Viscosity cP	Primer 6 intial Viscosity cP	1 hour Viscosity cP	2 hours Viscosity cP	Speed RPM
10.0	175.0	375.0	675.0	1500.0	575.0	650.0	750.0	2025.0	200.0	650.0	3075.0	10.0
50.0	125.0	265.0	465.0	1145.0	210.0	255.0	330.0	1195.0	105.0	420.0	2835.0	50.0
90.0	111.1	233.3	411.1	1080.6	155.6	197.2	263.9	1077.8	86.1	383.3	2841.7	90.0
130.0	103.8	217.3	380.8	1051.9	132.7	171.2	238.5	1030.8	76.9	369.2	2751.9	130.0
170.0	95.6	204.4	357.4	1033.8	119.1	157.4	220.6	1002.9	72.1	363.2	2102.9	170.0
210.0	94.0	197.6	340.5	1026.2	111.9	147.6	211.9	989.3	71.4	360.7	1607.1	210.0
250.0	89.0	190.0	329.0	1020.0	105.0	141.0	205.0	974.0	68.0	358.0	1350.0	250.0
210.0	91.7	190.5	327.4	1019.0	110.7	147.6	210.7	981.0	71.4	358.3	1607.1	210.0
170.0	92.6	194.1	329.4	1022.1	116.2	154.4	222.1	997.1	73.5	360.3	2102.9	170.0
130.0	96.2	198.1	336.5	1032.7	128.8	167.3	238.5	1021.2	78.8	365.4	2751.9	130.0
90.0	102.8	208.3	350.0	1052.8	147.2	191.7	261.1	1066.7	86.1	372.2	2841.7	90.0
50.0	110.0	230.0	385.0	1115.0	190.0	245.0	325.0	1170.0	100.0	390.0	2830.0	50.0
10.0	150.0	325.0	550.0	1475.0	500.0	600.0	725.0	1925.0	200.0	500.0	2875.0	10.0

Speed RPM	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Speed RPM
10.0	5.95	12.8	23.0	51.0	19.5	22.1	25.5	68.9	6.80	22.1	104.6	10.0
50.0	21.3	45.1	79.1	194.7	35.7	43.4	56.1	203.2	17.9	71.4	482.0	50.0
90.0	34.0	71.4	125.8	330.7	47.6	60.4	80.8	329.8	26.4	117.3	869.6	90.0
130.0	45.9	96.1	168.3	465.0	58.7	75.7	105.4	455.6	34.0	163.2	1216.4	130.0
170.0	55.3	118.2	206.6	597.6	68.9	91.0	127.5	579.7	41.7	210.0	1215.5	170.0
210.0	67.2	141.1	243.1	732.7	79.9	105.4	151.3	706.4	51.0	257.5	1147.5	210.0
250.0	75.7	161.5	279.7	867.0	89.3	119.9	174.3	827.9	57.8	304.3	1147.5	250.0
210.0	65.4	136.0	233.8	727.6	79.1	105.4	150.5	700.4	51.0	255.9	1147.5	210.0
170.0	53.6	112.2	190.4	590.8	67.2	89.3	128.4	576.3	42.5	208.3	1215.5	170.0
130.0	42.5	87.6	148.8	456.5	57.0	73.9	105.4	451.4	34.8	161.5	1216.4	130.0
90.0	31.5	63.8	107.1	322.2	45.1	58.7	79.9	326.4	26.4	113.9	869.6	90.0
50.0	18.7	39.1	65.4	189.6	32.3	41.7	55.3	198.9	17.0	66.3	481.1	50.0
10.0	5.10	11.1	18.7	50.2	17.0	20.4	24.7	65.4	6.80	17.0	97.8	10.0

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Appendix II

90 degrees F/20% RH

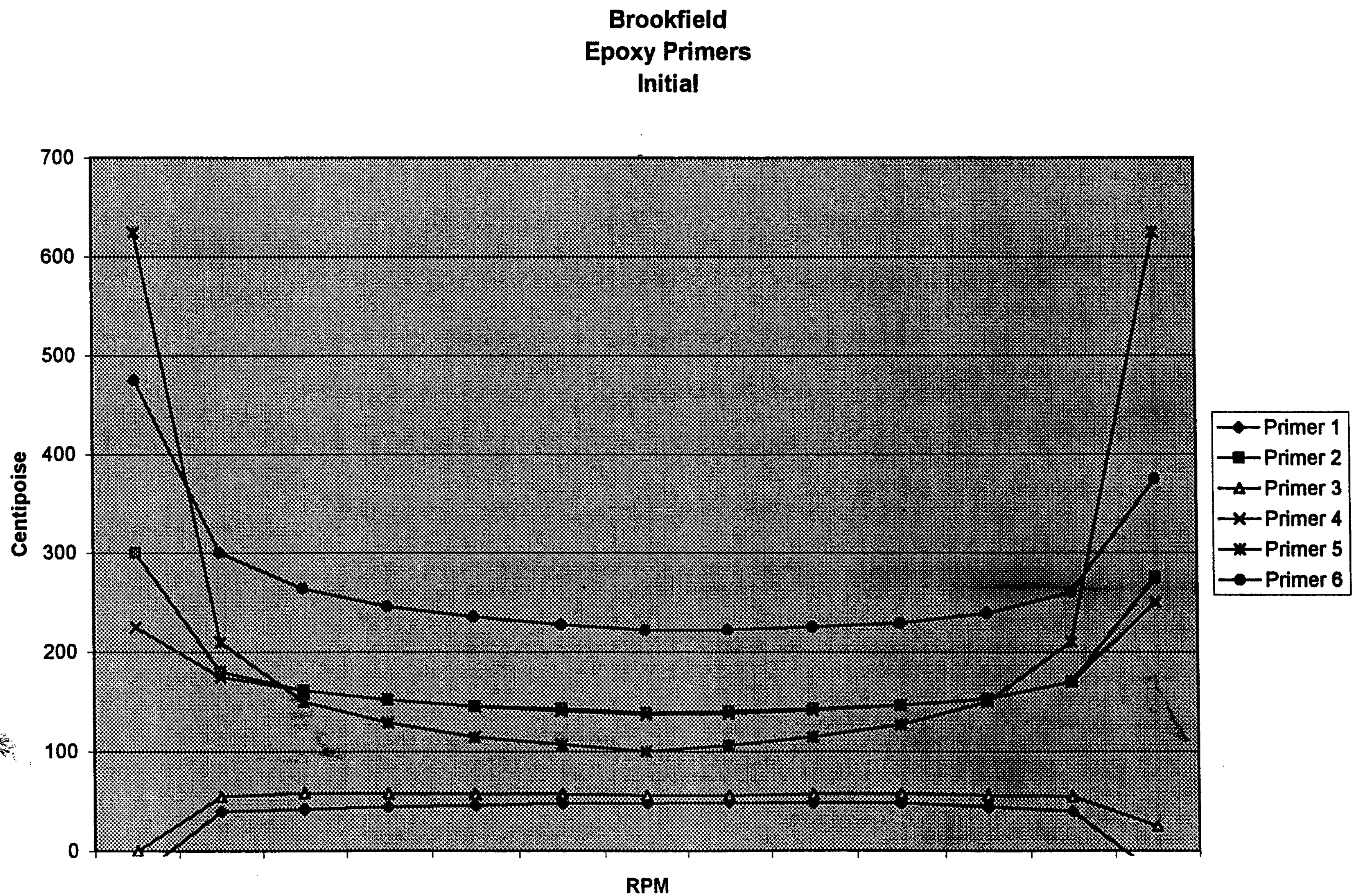
High Solids Primers
Brookfield Viscosity

Primer 7 initial Viscosity cP	1 hour Viscosity cP	2 hours Viscosity cP	4 hours Viscosity cP	Primer 8 initial Viscosity cP	1 hour Viscosity cP	2 hours Viscosity cP	Primer 9 initial Viscosity cP	Speed RPM
-25.00	0.00	75.0	450.0	125.0	175.0	275.0	300.0	10.0
15.0	30.0	80.0	430.0	115.0	165.0	265.0	290.0	50.0
19.4	30.6	75.0	422.2	111.1	163.9	261.1	286.1	90.0
19.2	28.8	75.0	417.3	109.6	161.5	261.5	284.6	130.0
17.6	29.4	72.1	413.2	108.8	161.8	261.8	282.4	170.0
19.0	28.6	70.2	413.1	110.7	160.7	263.1	283.3	210.0
18.0	28.0	72.0	413.0	110.0	161.0	263.0	283.0	250.0
17.9	28.6	72.6	416.7	111.9	160.7	266.7	284.5	210.0
19.1	27.9	75.0	422.1	114.7	164.7	270.6	286.8	170.0
17.3	30.8	76.9	430.8	115.4	165.4	273.1	292.3	130.0
19.4	27.8	77.8	436.1	116.7	166.7	275.0	294.4	90.0
15.0	30.0	75.0	450.0	125.0	170.0	285.0	300.0	50.0
-25.00	0.00	75.0	475.0	150.0	175.0	300.0	325.0	10.0

Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Speed RPM
-0.85	0.00	2.55	15.3	4.25	5.95	9.35	10.2	10.0
2.55	5.10	13.6	73.1	19.5	28.1	45.1	49.3	50.0
5.95	9.35	23.0	129.2	34.0	50.2	79.9	87.6	90.0
8.50	12.8	33.2	184.5	48.5	71.4	115.6	125.8	130.0
10.2	17.0	41.7	238.9	62.9	93.5	151.3	163.2	170.0
13.6	20.4	50.2	295.0	79.1	114.8	187.9	202.3	210.0
15.3	23.8	61.2	351.1	93.5	136.9	223.6	240.6	250.0
12.8	20.4	51.9	297.5	79.9	114.8	190.4	203.2	210.0
11.1	16.1	43.4	244.0	66.3	95.2	156.4	165.8	170.0
7.65	13.6	34.0	190.4	51.0	73.1	120.7	129.2	130.0
5.95	8.50	23.8	133.4	35.7	51.0	84.2	90.1	90.0
2.55	5.10	12.8	76.5	21.3	28.9	48.5	51.0	50.0
-0.85		2.55	16.1	5.10	5.95	10.2	11.1	10.0

90 degrees F/80% RH

High Solids Primers

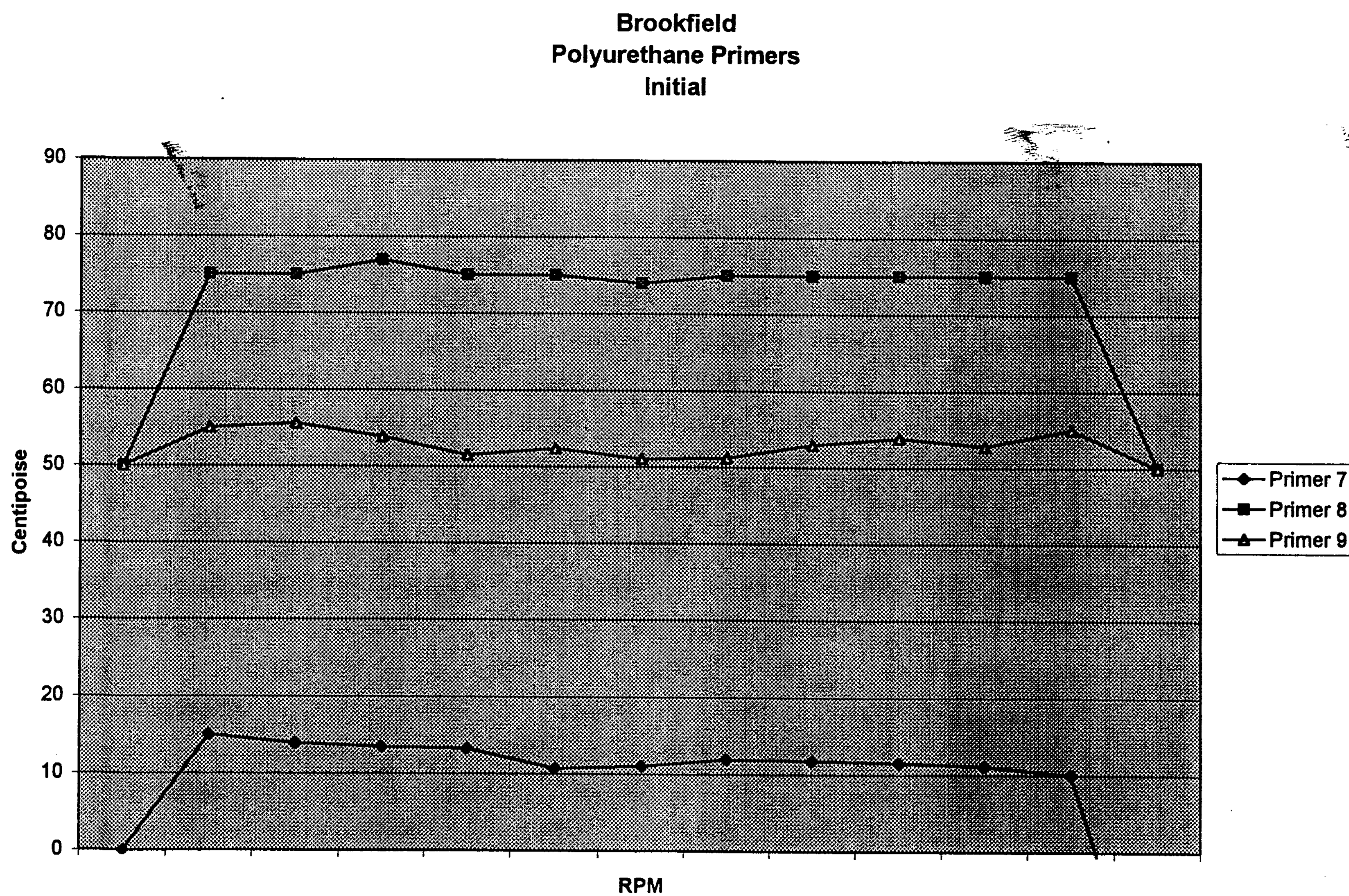


10 RPM to 250 RPM to 10 RPM

Appendix II

90 degrees F/80% RH

High Solids Primers



10 RPM to 250 RPM to 10 RPM

Appendix II

90 degrees F/80% RH

High Solids Primers
Brookfield Viscosity

Speed RPM	Primer 1 initial Viscosity cP	1 hour Viscosity cP	2 hours Viscosity cP	Primer 2 initial Viscosity cP	1 hour Viscosity cP	2 hours Viscosity cP	Primer 3 initial Viscosity cP	1 hour Viscosity cP	2 hours Viscosity cP
10.0	-25.00	50.0	250.0	300.0	900.0	2950.0	0.00	100.0	375.0
50.0	40.0	105.0	300.0	180.0	730.0	2690.0	55.0	135.0	390.0
90.0	41.7	111.1	305.6	161.1	697.2	2591.7	58.3	133.3	372.2
130.0	44.2	113.5	307.7	151.9	676.9	2513.5	57.7	134.6	359.6
170.0	45.6	114.7	305.9	145.6	660.3	2104.4	57.4	133.8	344.1
210.0	47.6	115.5	303.6	142.9	648.8	1703.6	57.1	134.5	333.3
250.0	48.0	115.0	301.0	139.0	642.0	1350.0	56.0	133.0	325.0
210.0	48.8	115.5	304.8	140.5	639.3	1703.6	56.0	134.5	325.0
170.0	48.5	116.2	311.8	142.6	642.6	2104.4	57.4	135.3	329.4
130.0	48.1	117.3	321.2	146.2	648.1	2357.7	57.7	136.5	336.5
90.0	44.4	116.7	336.1	152.8	650.0	2375.0	55.6	138.9	347.2
50.0	40.0	115.0	355.0	170.0	675.0	2420.0	55.0	140.0	360.0
10.0	-25.00	50.0	325.0	275.0	825.0	2675.0	25.0	100.0	375.0

Speed RPM	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2
10.0	-0.85	1.70	8.50	10.2	30.6	100.3	0.00	3.40	12.8
50.0	6.80	17.9	51.0	30.6	124.1	457.3	9.35	23.0	66.3
90.0	12.8	34.0	93.5	49.3	213.4	793.1	17.9	40.8	113.9
130.0	19.5	50.2	136.0	67.2	299.2	1110.9	25.5	59.5	159.0
170.0	26.4	66.3	176.8	84.2	381.7	1216.4	33.2	77.4	198.9
210.0	34.0	82.4	216.8	102.0	463.3	1216.4	40.8	96.1	238.0
250.0	40.8	97.8	255.9	118.2	545.7	1147.5	47.6	113.1	276.3
210.0	34.8	82.4	217.6	100.3	456.5	1216.4	40.0	96.1	232.1
170.0	28.1	67.2	180.2	82.4	371.5	1216.4	33.2	78.2	190.4
130.0	21.3	51.9	142.0	64.6	286.5	1042.1	25.5	60.4	148.8
90.0	13.6	35.7	102.9	46.8	198.9	726.8	17.0	42.5	106.3
50.0	6.80	19.5	60.4	28.9	114.8	411.4	9.35	23.8	61.2
10.0	-0.85	1.70	11.1	9.35	28.1	91.0	0.85	3.40	12.8

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Appendix II

90 degrees F/80% RH

High Solids Primers
Brookfield Viscosity

Speed RPM	Primer 4 initial Viscosity cP	1 hour Viscosity cP	2 hours Viscosity cP	Speed RPM	Primer 5 initial Viscosity cP	1 hour Viscosity cP	Primer 6 initial Viscosity cP	1 hour Viscosity cP
10.0	225.0	200.0	450.0	10.0	625.0	1400.0	475.0	1200.0
50.0	175.0	160.0	335.0	50.0	210.0	570.0	300.0	1005.0
90.0	161.1	147.2	308.3	90.0	150.0	450.0	263.9	925.0
130.0	151.9	140.4	294.2	130.0	128.8	398.1	246.2	871.2
170.0	145.6	135.3	283.8	170.0	114.7	369.1	235.3	845.6
210.0	140.5	129.8	276.2	210.0	107.1	348.8	227.4	829.8
250.0	137.0	127.0	270.0	250.0	100.0	335.0	222.0	815.0
210.0	138.1	127.4	271.4	210.0	106.0	342.9	222.6	813.1
170.0	141.2	130.9	275.0	170.0	114.7	355.9	225.0	817.6
130.0	146.2	134.6	280.8	130.0	126.9	380.8	228.8	825.0
90.0	152.8	141.7	291.7	90.0	150.0	422.2	238.9	838.9
50.0	170.0	155.0	315.0	50.0	210.0	530.0	260.0	860.0
10.0	250.0	225.0	450.0	10.0	625.0	1325.0	375.0	975.0

Speed RPM	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Speed RPM	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2
10.0	7.65	6.80	15.3	10.0	21.3	47.6	16.1	40.8
50.0	29.8	27.2	57.0	50.0	35.7	96.9	51.0	170.9
90.0	49.3	45.1	94.4	90.0	45.9	137.7	80.8	283.0
130.0	67.2	62.1	130.1	130.0	57.0	176.0	108.8	385.1
170.0	84.2	78.2	164.1	170.0	66.3	213.4	136.0	488.8
210.0	100.3	92.7	197.2	210.0	76.5	249.1	162.4	592.5
250.0	116.5	108.0	229.5	250.0	85.0	284.8	188.7	692.8
210.0	98.6	91.0	193.8	210.0	75.7	244.8	159.0	580.6
170.0	81.6	75.7	159.0	170.0	66.3	205.7	130.1	472.6
130.0	64.6	59.5	124.1	130.0	56.1	168.3	101.2	364.7
90.0	46.8	43.4	89.3	90.0	45.9	129.2	73.1	256.7
50.0	28.9	26.4	53.6	50.0	35.7	90.1	44.2	146.2
10.0	8.50	7.65		10.0	21.3	45.1	12.8	

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Appendix II

Speed RPM	Primer 7 initial Viscosity cP	1 hour Viscosity cP	Primer 8 initial Viscosity cP	Primer 9 initial Viscosity cP	1 hour Viscosity cP
10.0	0.00	-25.00	50.0	50.0	275.0
50.0	15.0	15.0	75.0	55.0	295.0
90.0	13.9	19.4	75.0	55.6	294.4
130.0	13.5	19.2	76.9	53.8	290.4
170.0	13.2	19.1	75.0	51.5	289.7
210.0	10.7	19.0	75.0	52.4	286.9
250.0	11.0	19.0	74.0	51.0	285.0
210.0	11.9	19.0	75.0	51.2	284.5
170.0	11.8	19.1	75.0	52.9	285.3
130.0	11.5	19.2	75.0	53.8	286.5
90.0	11.1	16.7	75.0	52.8	286.1
50.0	10.0	15.0	75.0	55.0	290.0
10.0	-25.00	-25.00	50.0	50.0	275.0

Speed RPM	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2	Shear Stress D/Cm2
10.0	0.00	-0.85	1.70	1.70	9.35
50.0	2.55	2.55	12.8	9.35	50.2
90.0	4.25	5.95	23.0	17.0	90.1
130.0	5.95	8.50	34.0	23.8	128.4
170.0	7.65	11.1	43.4	29.8	167.5
210.0	7.65	13.6	53.6	37.4	204.9
250.0	9.35	16.1	62.9	43.4	242.3
210.0	8.50	13.6	53.6	36.6	203.2
170.0	6.80	11.1	43.4	30.6	164.9
130.0	5.10	8.50	33.2	23.8	126.7
90.0	3.40	5.10	23.0	16.1	87.6
50.0	1.70	2.55	12.8	9.35	49.3
10.0	-0.85	-0.85	1.70	1.70	9.35

APPENDIX III

High Solids Primers
CIELab Values

Primer	77/50			60/20			60/80			90/20			90/80		
	L*	a*	b*	L*	a*	b*	L*	a*	b*	L*	a*	b*	L*	a*	b*
	MIL-C-85285 Gloss Topcoat, Color 16473														
1	69.185	-3.750	0.865	69.857	-3.719	0.370				69.965	-3.747	0.394	69.176	-3.832	0.697
2	69.271	-3.762	0.696	69.878	-3.739	0.417	69.396	-3.684	0.462	69.790	-3.738	0.259	70.356	-3.788	1.215
3	69.404	-3.777	0.745	67.764	-3.614	0.307	69.518	-3.710	0.534	69.662	-3.740	0.246	69.407	-4.107	2.002
4	69.413	-3.982	1.915	69.730	-3.747	0.372	69.621	-3.685	0.474	69.783	-3.746	0.305	68.847	-4.053	1.831
5	69.215	-3.749	0.865	69.709	-3.730	0.412	69.469	-3.718	0.478	69.788	-3.748	0.351	68.916	-3.809	0.710
6	69.349	-3.782	0.821	69.726	-3.750	0.483	69.477	-3.703	0.473	69.599	-3.730	0.363	69.053	-3.775	0.694
7	69.407	-3.824	0.665	69.607	-3.712	0.469	69.732	-3.702	0.469	69.867	-3.736	0.331	68.970	-3.804	0.906
8	69.463	-3.828	0.832	69.803	-3.734	0.465	69.803	-3.757	0.442	69.592	-3.748	0.286	69.229	-3.798	0.693
9	69.346	-3.824	0.772	69.684	-3.718	0.569	69.732	-3.755	0.367	69.853	-3.739	0.348	69.110	-3.802	0.714
	MIL-C-85285 Camouflage Topcoat, Color 36173														
1	48.934	-1.158	-3.699	48.828	-1.323	-4.162				49.182	-1.388	-4.119	49.716	-1.251	-3.945
2	48.259	-1.233	-3.821	47.808	-1.327	-4.075	48.253	-1.409	-4.069	49.476	-1.361	-4.107	49.429	-1.271	-3.787
3	48.832	-1.191	-3.697	48.789	-1.329	-4.095	49.239	-1.386	-4.103	49.432	-1.372	-4.120	49.510	-1.321	-3.720
4	48.430	-1.153	-3.694	46.576	-1.311	-3.991	48.124	-1.432	-4.121	48.634	-1.340	-4.035	49.773	-1.254	-3.854
5	48.338	-1.337	-2.659	48.140	-1.312	-4.014	48.983	-1.424	-4.036	49.446	-1.379	-4.119	49.589	-1.300	-3.809
6	48.704	-1.206	-3.760	48.800	-1.336	-4.160	49.393	-1.388	-4.030	49.407	-1.382	-4.083	49.834	-1.277	-3.784
7	48.432	-1.188	-3.684	Finish-Mudcracked			48.820	-1.378	-4.047	48.968	-1.335	-4.093	49.909	-1.243	-3.772
8	48.178	-1.190	-3.634	48.979	-1.399	-4.252	48.538	-1.352	-3.838	49.116	-1.426	-4.204	49.654	-1.317	-3.811
9	48.641	-1.271	-3.857	49.023	-1.379	-4.191	48.735	-1.374	-3.795	49.268	-1.377	-4.229	49.688	-1.313	-3.823

	Average-Gloss Topcoat			Average-Camouflage Topcoat		
	L*	a*	b*	L*	a*	b*
1	69.546	-3.762	0.582	49.165	-1.280	-3.981
2	69.738	-3.742	0.610	48.645	-1.320	-3.972
3	69.151	-3.790	0.767	49.160	-1.320	-3.947
4	69.479	-3.843	0.979	48.307	-1.298	-3.939
5	69.419	-3.751	0.563	48.899	-1.350	-3.727
6	69.441	-3.748	0.567	49.228	-1.318	-3.963
7	69.517	-3.756	0.568	49.032	-1.286	-3.899
8	69.578	-3.773	0.544	48.893	-1.337	-3.948
9	69.545	-3.768	0.554	49.071	-1.343	-3.979

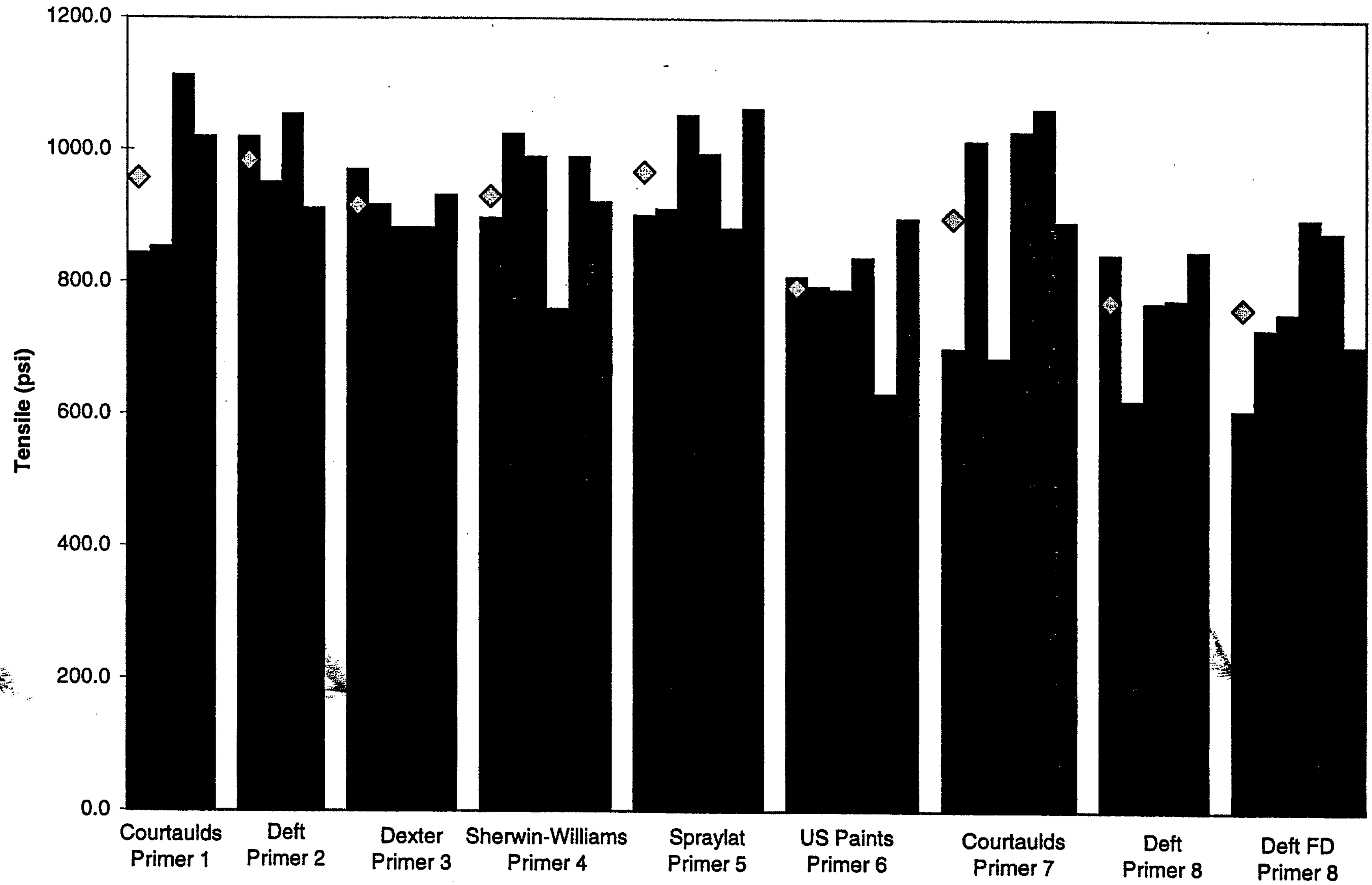
Appendix III

APPENDIX IV

77 degrees F/50% RH

High Solids Primers

PATTI Test, Initial



PATTI Test.

Appendix IV

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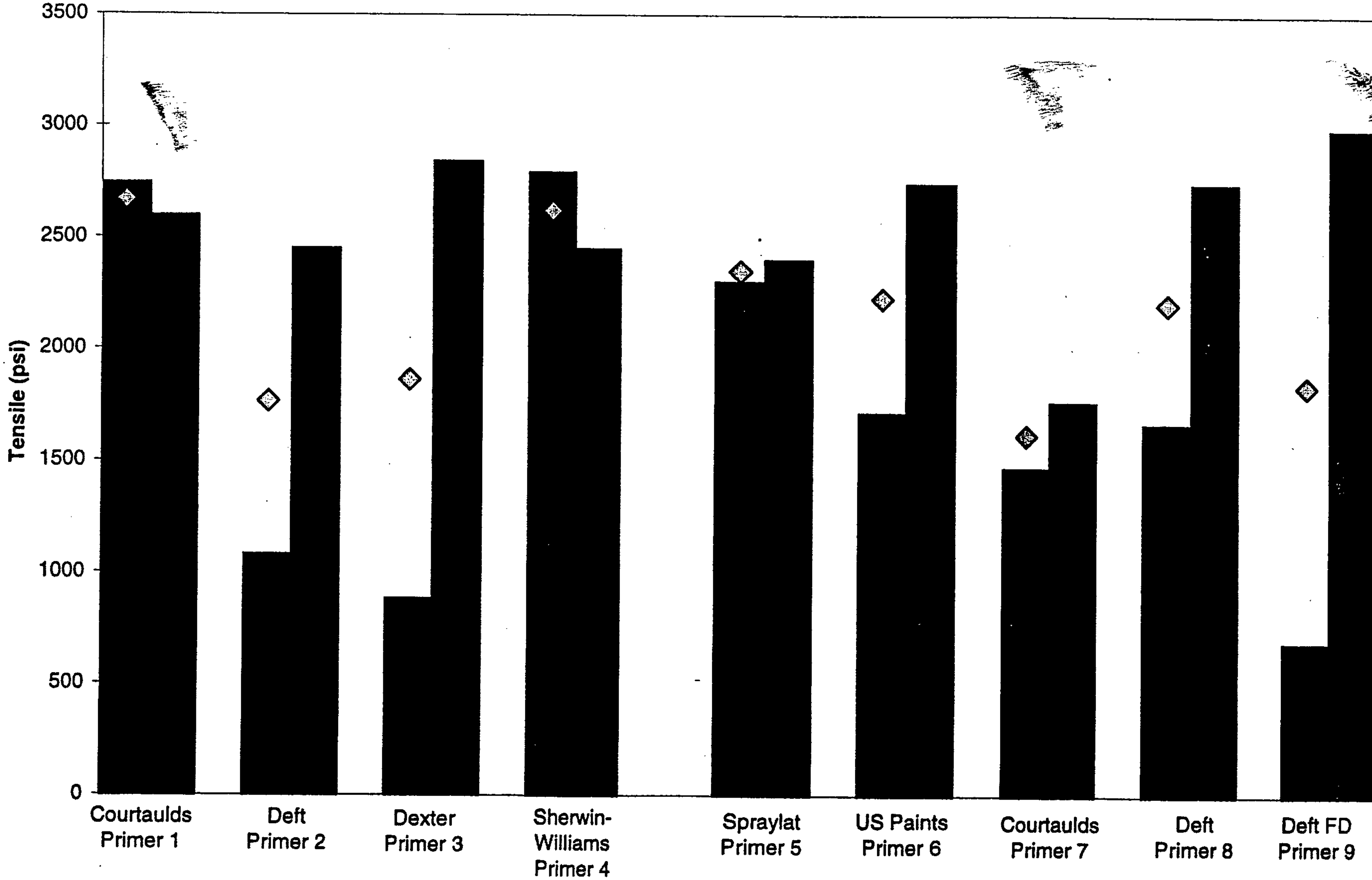
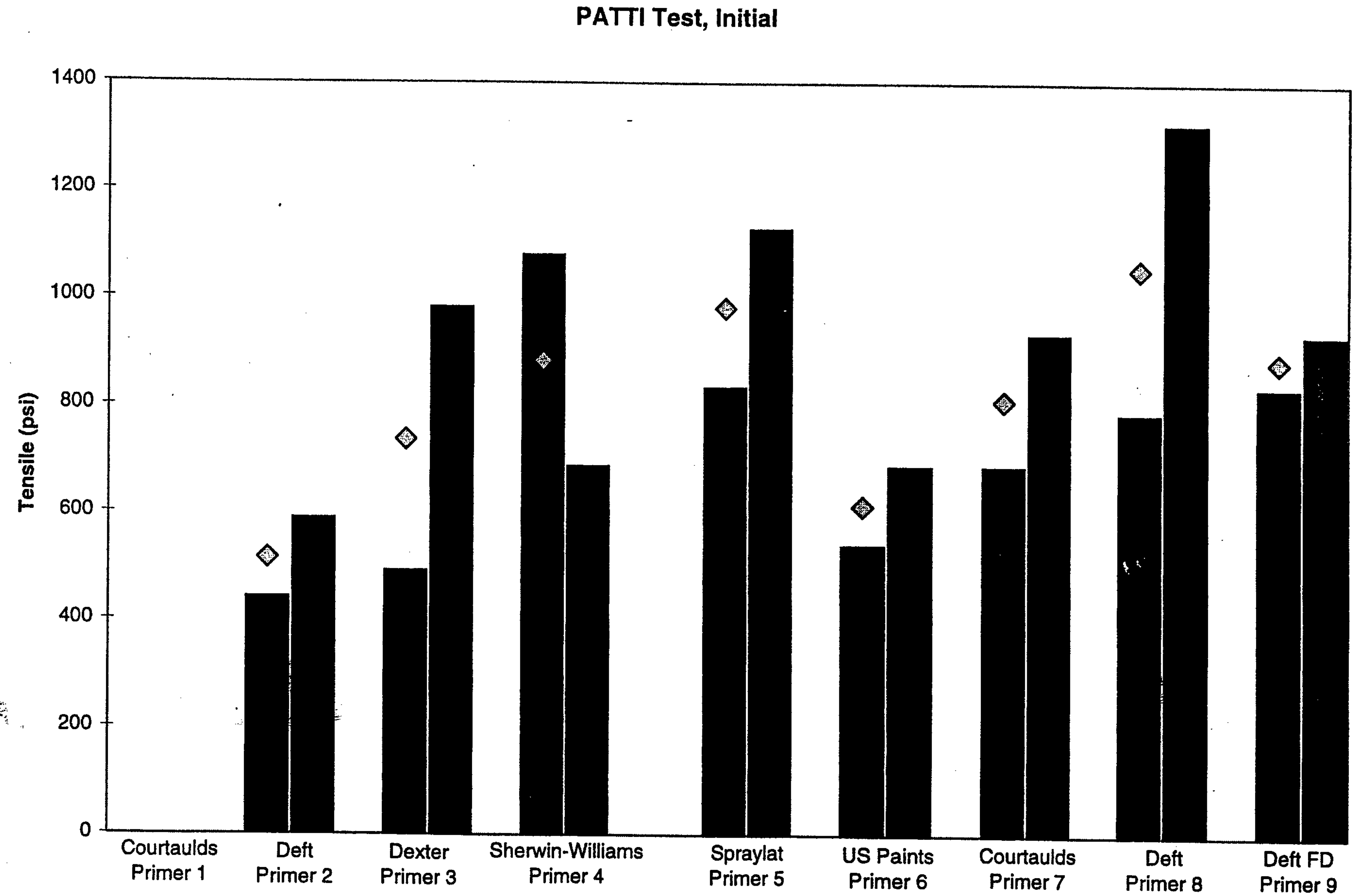
PATTI Test, Initial



60 degrees F/80% RH

High Solids Primers



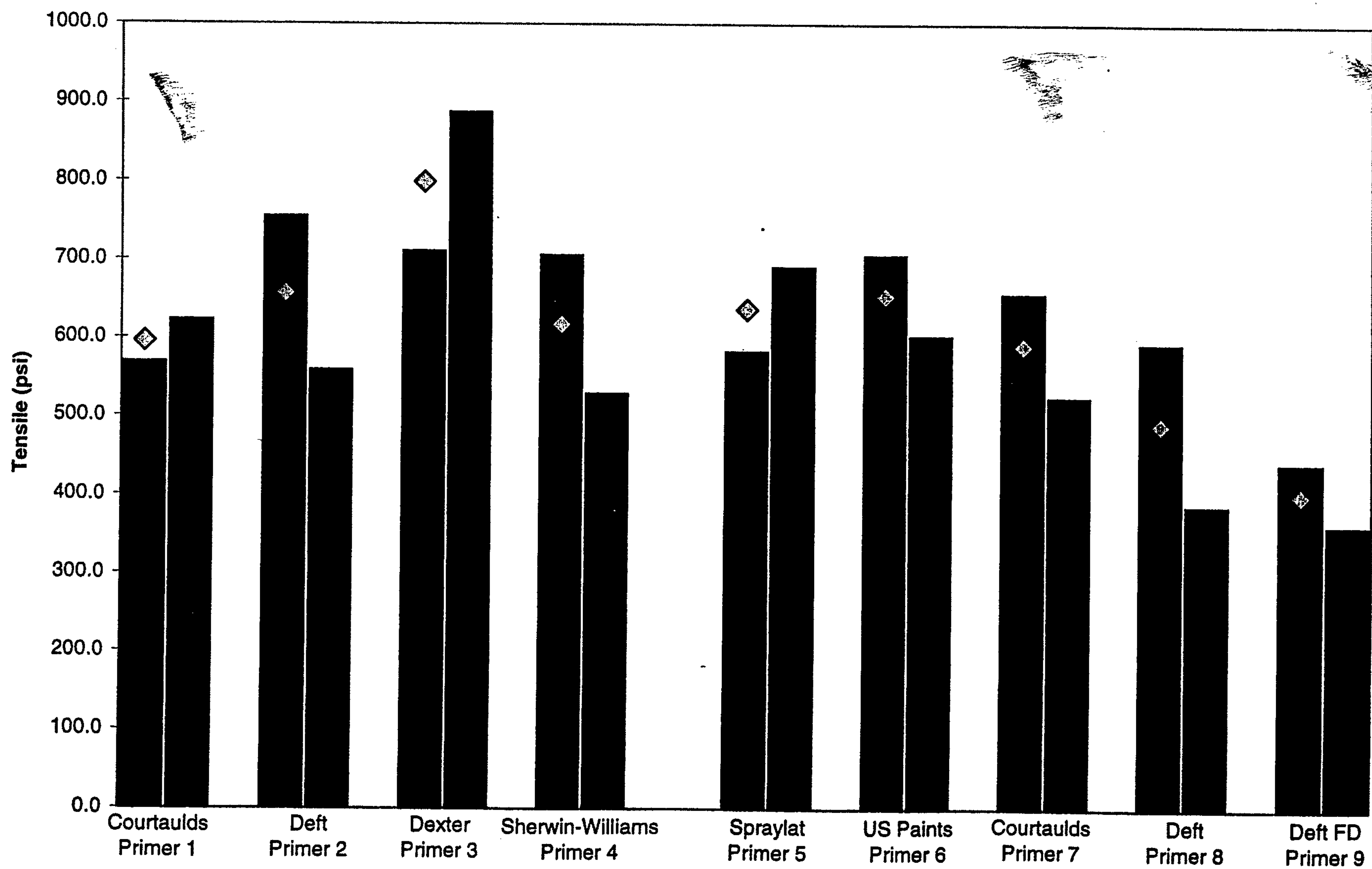
Appendix IV

PATTI Test

90 degrees F/20% RH

High Solids Primers

PATTI Test, Initial



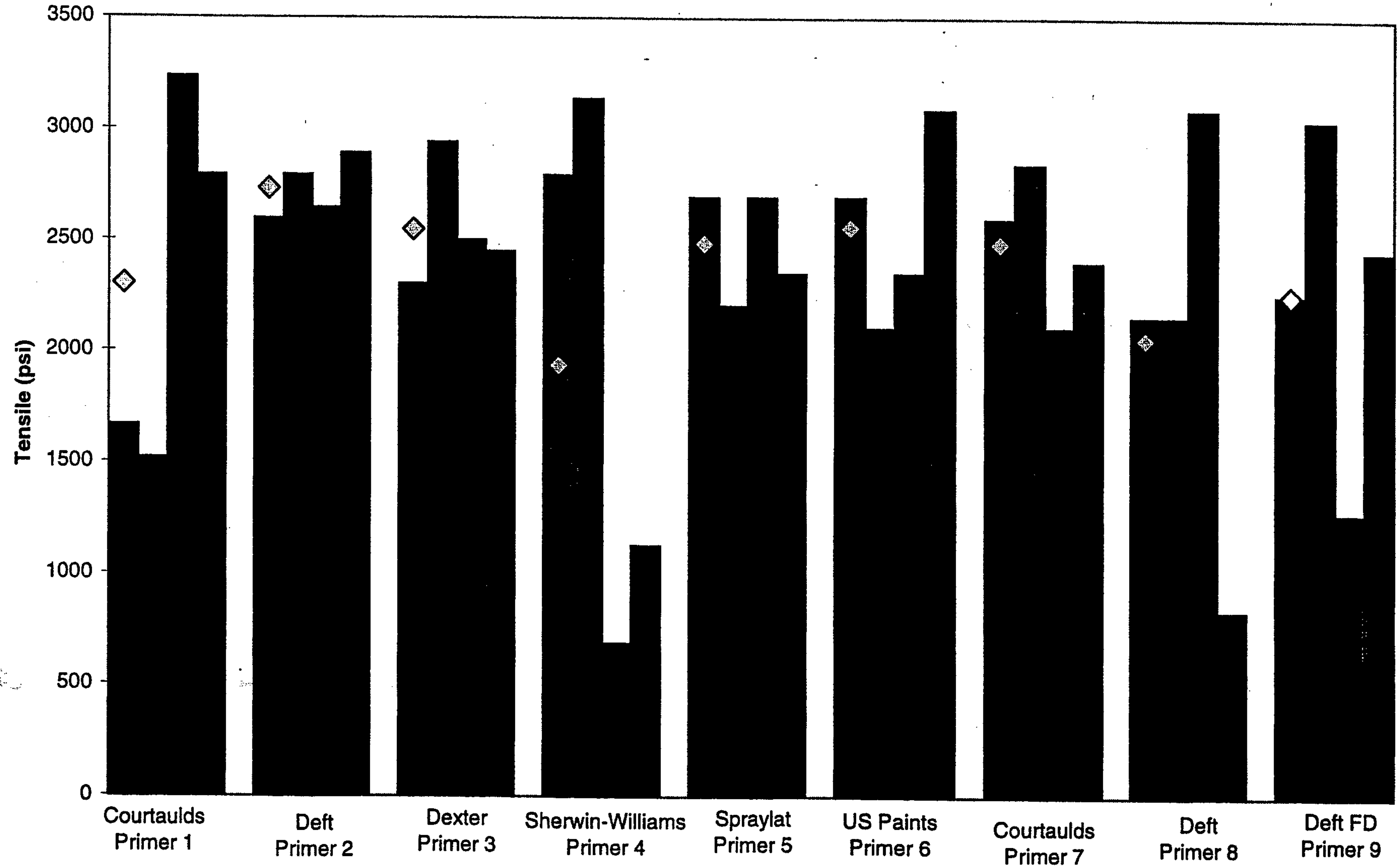
PATTI Test·

Appendix IV

90 degrees F/80% RH

High Solids Primers

PATTI Test, Initial



PATTI Test

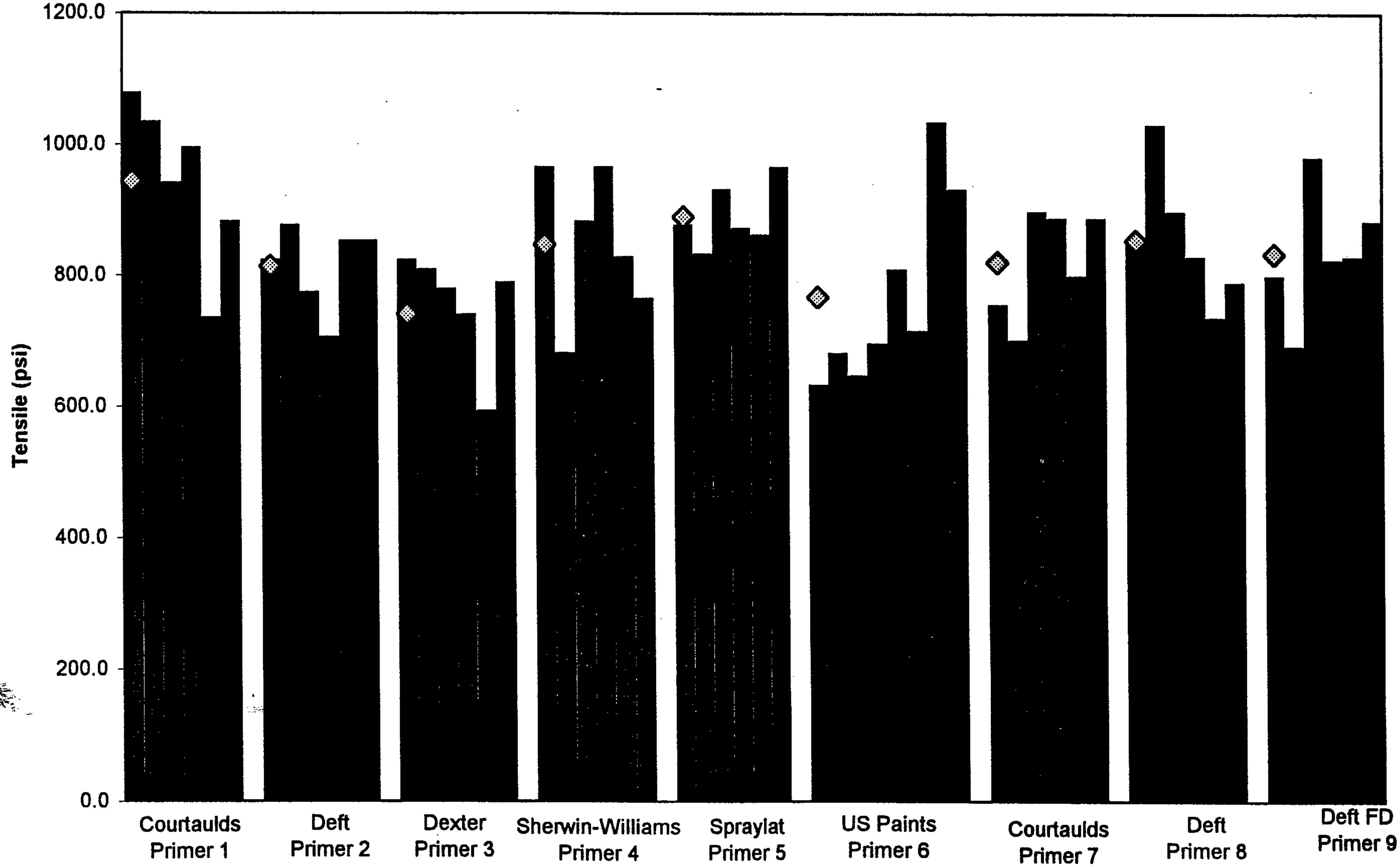
Appendix IV

APPENDIX V

77 degrees F/50% RH

High Solids Primers

PATTI Test, Water Immersion



PATTI Test

Appendix V

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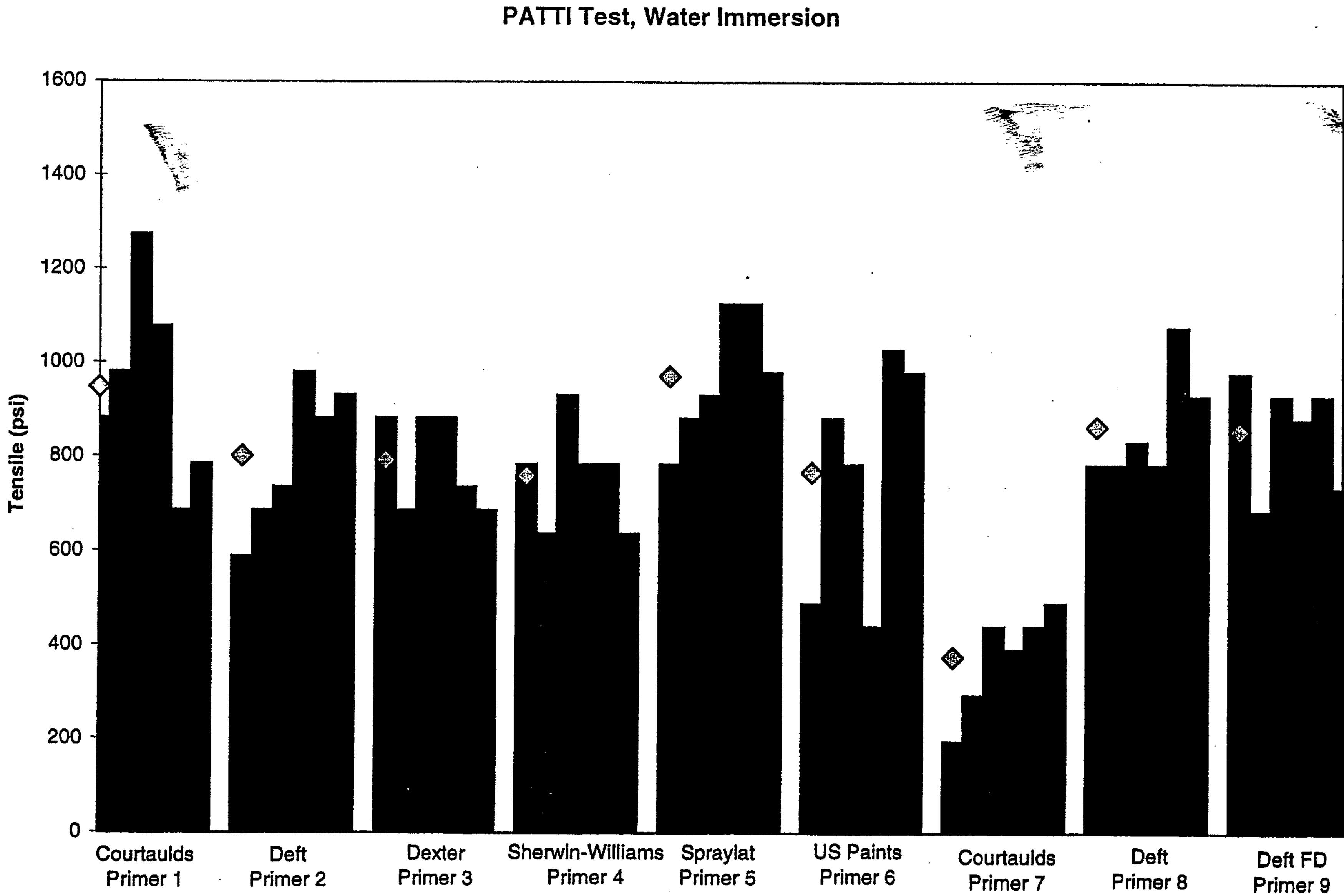
60 degrees F/20% RH

High Solids Primers

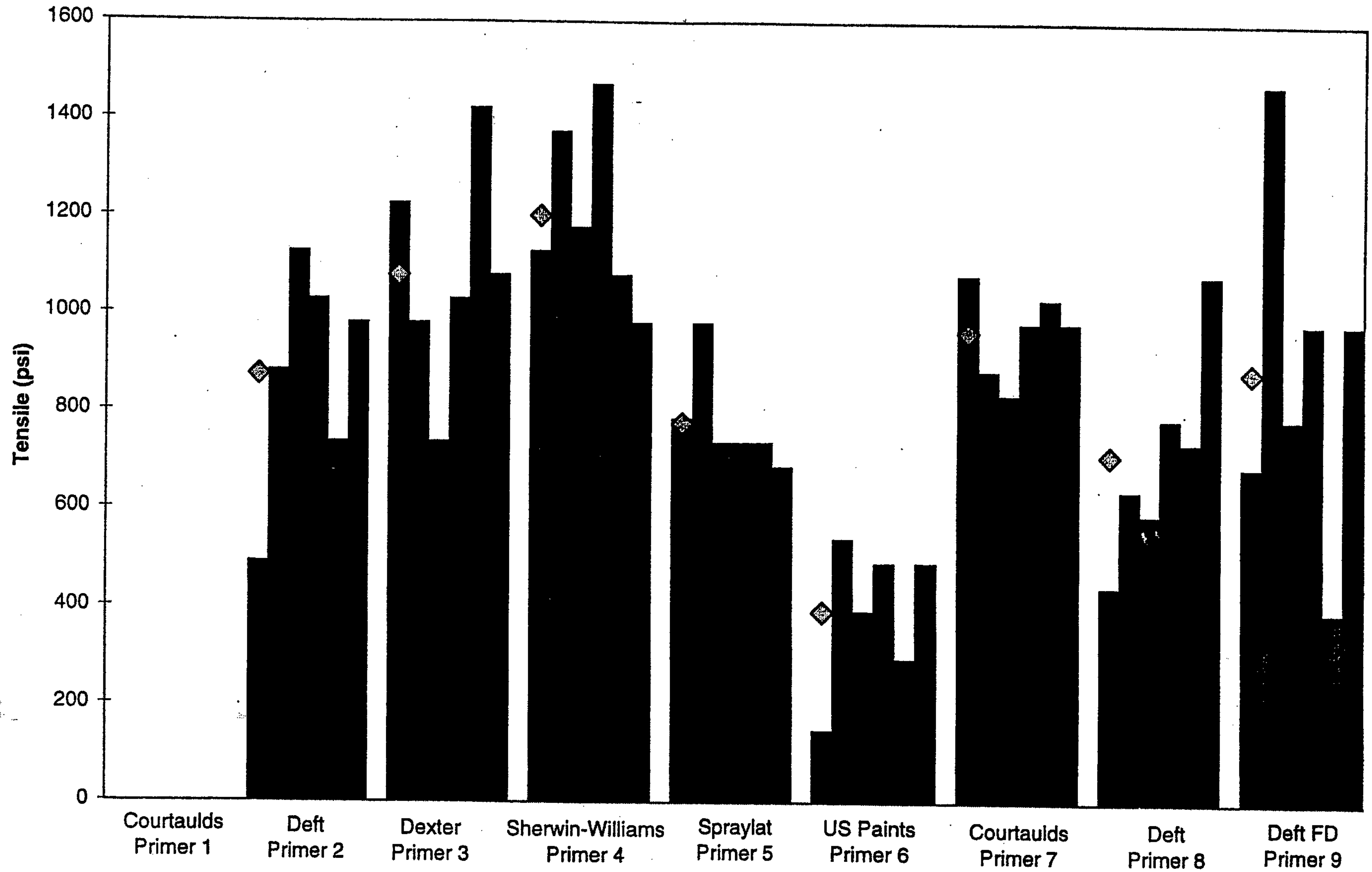


Appendix V

60 degrees F/80% RH

High Solids Primers

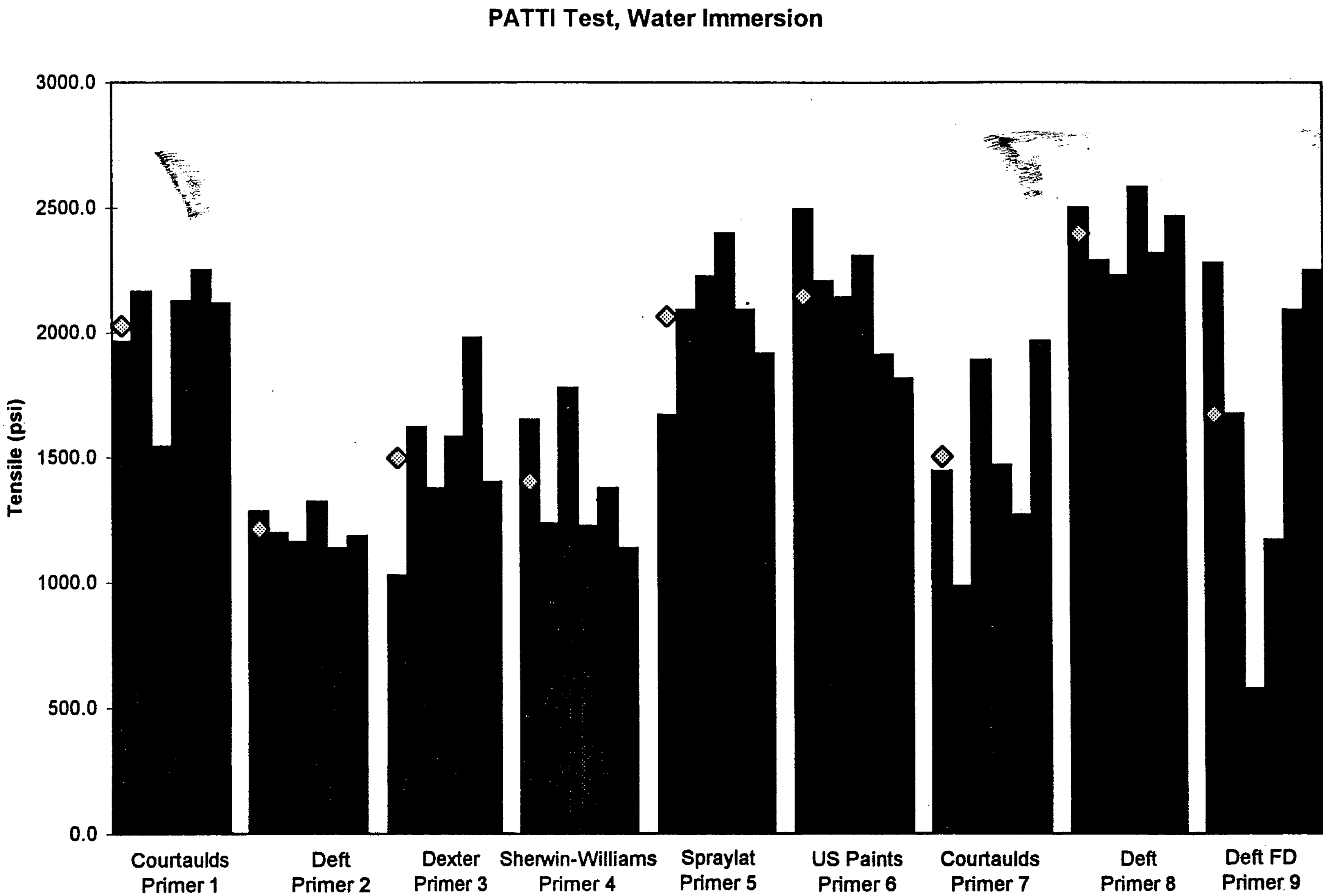
PATTI Test, Water Immersion



PATTI Test

Appendix V

64

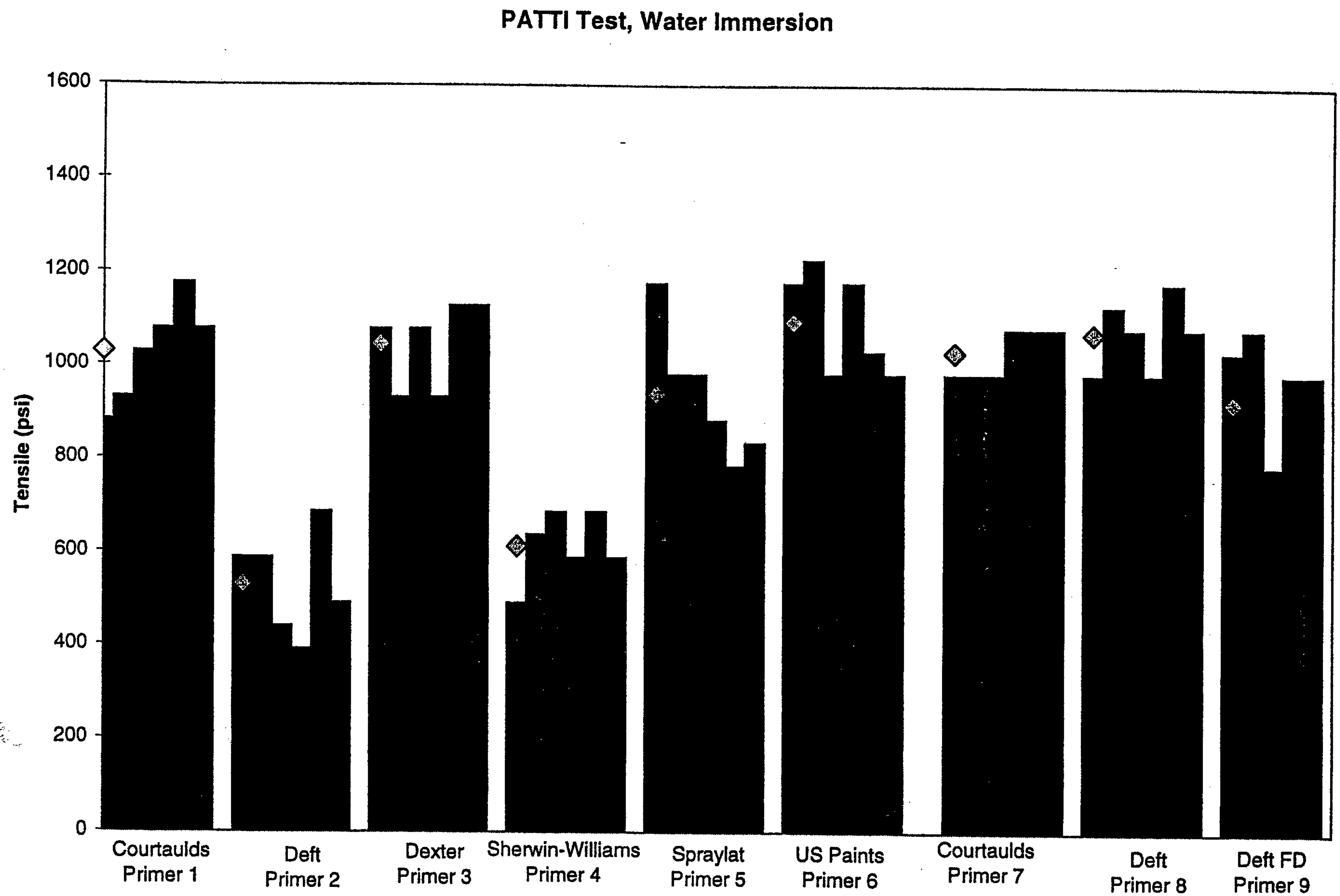


65

Appendix V

90 degrees F/80% RH

High Solids Primers



Appendix V